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REPORT

October 30, 2020

TOWN OF
Nantucket
MASSACHUSETTS

Anaerobic Digester Feasibility Study

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EXECUTIVE SUMMARY

Weston & Sampson, on behalf of the Town of Nantucket, has completed this Feasibility Study, which examines the technological and economic aspects of implementing an anaerobic digestion project in the Town of Nantucket, MA. Based on the results of this study, the construction and operation of an anaerobic digestion facility at the existing Surfside Wastewater Treatment Facility (WWTF) is recommended as a technically feasible and economically possible endeavor.

The economic feasibility, though strained and dependent on funding and financing options, is most viable under a public ownership model. Total, probable costs for the project range in order of magnitude from $15,000,000 to $20,000,000, with annual net costs, not including revenue sources or cost savings against the existing, baseline process between $1,200,000 and $1,600,000. When considering the savings in electricity, heating oil, and biosolids disposal fees, the annual costs adjust to between $900,000 and $1,400,000. The Town will need to further consider the economics of the digester project along with related issues such as limited landfill capacity, energy independence, and environmental stewardship.

It is technically feasible to incorporate anaerobic digestion into the solids handling process at the Surfside WWTF. The WWTF site and operational impacts are minimal and within existing design constraints of the WWTF. The addition of anaerobic digestion will increase the influent ammonia load and warrants further analysis to assess the possible impacts to the WWTF processes to ensure adequate treatment is maintained.

Recommended next steps include continued and additional project development to further consider the economics of building and operating an anaerobic digester at the Surfside WWTF. The additional project development includes:

- Further review and additional discussions with state and federal agencies regarding the potential of additional grants for an anaerobic digester on Nantucket.
- Further review of potential Renewable, Alternative, and Clean Peak Energy Certificates available for Nantucket.
- Further discussions with major SSO producers on the island to develop relationships and get commitments to ensure additional feedstock to the digester.
- Further review and implementation of a plan to get more fats, oils, and grease (FOG) into the digester. Based on records from the Sewer Department, only 8,900 gallons per year are trucked to the WWTF. The Town is currently updating the FOG regulations for restaurants and food service establishments. However, without enforcement of the regulations to require installation and maintenance (including routine pump out and cleaning), this will remain an issue for the Sewer Department. The town would also benefit from a system to acquire grease directly from homeowners, including those on both town sewer and private septic systems. The grease from homes on private septic systems likely ends up in the trash.
- The Town does not currently charge tipping fees for solid waste disposal at the landfill or FOG disposal at the WWTF. Additional consideration for the implementation of a system of

tipping fees could encourage disposal of certain feedstocks to the digester as opposed to the landfill.

- Further consideration of the economics of the digester project along with the value of related issues such as limited landfill capacity, energy independence, and environmental stewardship.

Acknowledgements

Weston & Sampson wishes to acknowledge the support and technical guidance provided by the many people who have invested time in this most valuable project. The completion of this report could not have been accomplished without the support from the following people:

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The Massachusetts Clean Energy Center (MassCEC)
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Various New England Wastewater Process Equipment Vendors

While the development of this report has been tested by the challenges of COVID-19, we feel that the final concept is a project worthy of serious consideration and, if constructed, has the potential to greatly benefit the Town of Nantucket.

Thank you all for your part in helping Weston & Sampson in the development of this report. Your contributions are greatly appreciated.

1.0 PROJECT OBJECTIVES AND ASSESSMENT OF EXISTING CONDITIONS

1.1 Project Objectives

This study is intended to assess the technical feasibility and economic viability of an anaerobic digester (AD) facility with combined heat and power (CHP) generation in Nantucket. As part of the assessment, a conceptual design is presented along with an estimate of probable of costs. The inherent benefits provided by anaerobic digestion such as waste solids volume reduction and energy generation take on greater significance in a small island community such as the Town of Nantucket, which relies on power from the mainland and costly shipping of any materials that must come to or from the island by air or sea. The expenses anticipated for shipping waste off island and constructing a third undersea cable for electricity are significant and increase the value associated with development of renewable energy and waste reduction alternatives available on island. As a result, the goals of this study are to determine the ability of the proposed anaerobic digestion facility to reduce costs for the Town, provide renewable energy, and reduce waste production and landfill storage needs, improving overall sustainability.

1.2 Assessment of Project Site and Vicinity

The proposed location of this anaerobic digestion project is at the existing site of the Surfside Wastewater Treatment Facility (WWTF). The Surfside WWTF and the property on which it is located, 81 S Shore Road, Nantucket, MA, (Site) are owned by the Town of Nantucket and situated on the south side of the island; the southernmost property line abuts the Atlantic Ocean. Figure 1, below, shows the location of the Surfside WWTF as well as the locations of the Siasconset WWTF and Town Landfill. The 39.3-acre property is partially developed with buildings structures dedicated to the wastewater treatment process. Figure 2 shows the existing layout of the Surfside WWTF.

Figure 1 - Nantucket Locus Map: WWTFs and Waste Disposal Sites

Figure 2 - Layout of Surfside WWTF

1.2.1 Land Use and Abutters

The zoning classification of the Site is Limited Use General – 3 (LUG-3) as referenced in the Code of Nantucket Division 1 Bylaws (Part II, § 139). As the site already houses a wastewater treatment facility, the addition of a digester and organics handling facility would not notably change the character of the property nor substantially increase the footprint of the treatment area. Other land adjacent to the property is undeveloped and classified as either open land or forest. Much of the area adjacent to the property is owned by the Town. The nearest residential property not owned by the Town is located approximately 500 feet to the northwest of the Site entrance. For the nearby, residential property that is privately owned, there will be little to no discernable change in the site. There will be some temporary, increased traffic during the construction phase, though that traffic will not route through the neighborhoods directly. After the completion of the project, there will be no significant impact to any of the proximate land areas.

1.2.2 Potential Environmental Hazards, Sensitive Receptors, and Resource Areas

The following environmental data sets acquired from the Massachusetts Office of Geographic Information (MassGIS) were used to determine whether any known hazards, sensitive receptors, or other environmental resources might pose a concern for this project.

- Department of Conservation and Recreation Areas of Critical Environmental Concern (ACEC)
- Massachusetts Department of Environmental Protection (DEP) Wetlands Inventory
- Massachusetts Division of Fisheries and Wildlife Natural Heritage and Endangered Species Program (NHESP) inventory, including:
    - Certified or Potential Vernal Pools
    - Estimated Habitats of Rare Wildlife
    - Priority Habitats of Rare Species
    - Natural Communities
- Federal Emergency Management Agency (FEMA) Flood Insurance Rate Mapping (FIRM)

There is a DEP wetland identified beach/dune area on the southernmost boundary of the site, though the proposed conceptual design does not impact this area. All other data sets did not indicate the presence of environmental hazards, sensitive receptors, or resources in the project site. The listed hazards, sensitive receptors, or lack thereof are shown on Figure 3 on the following page.

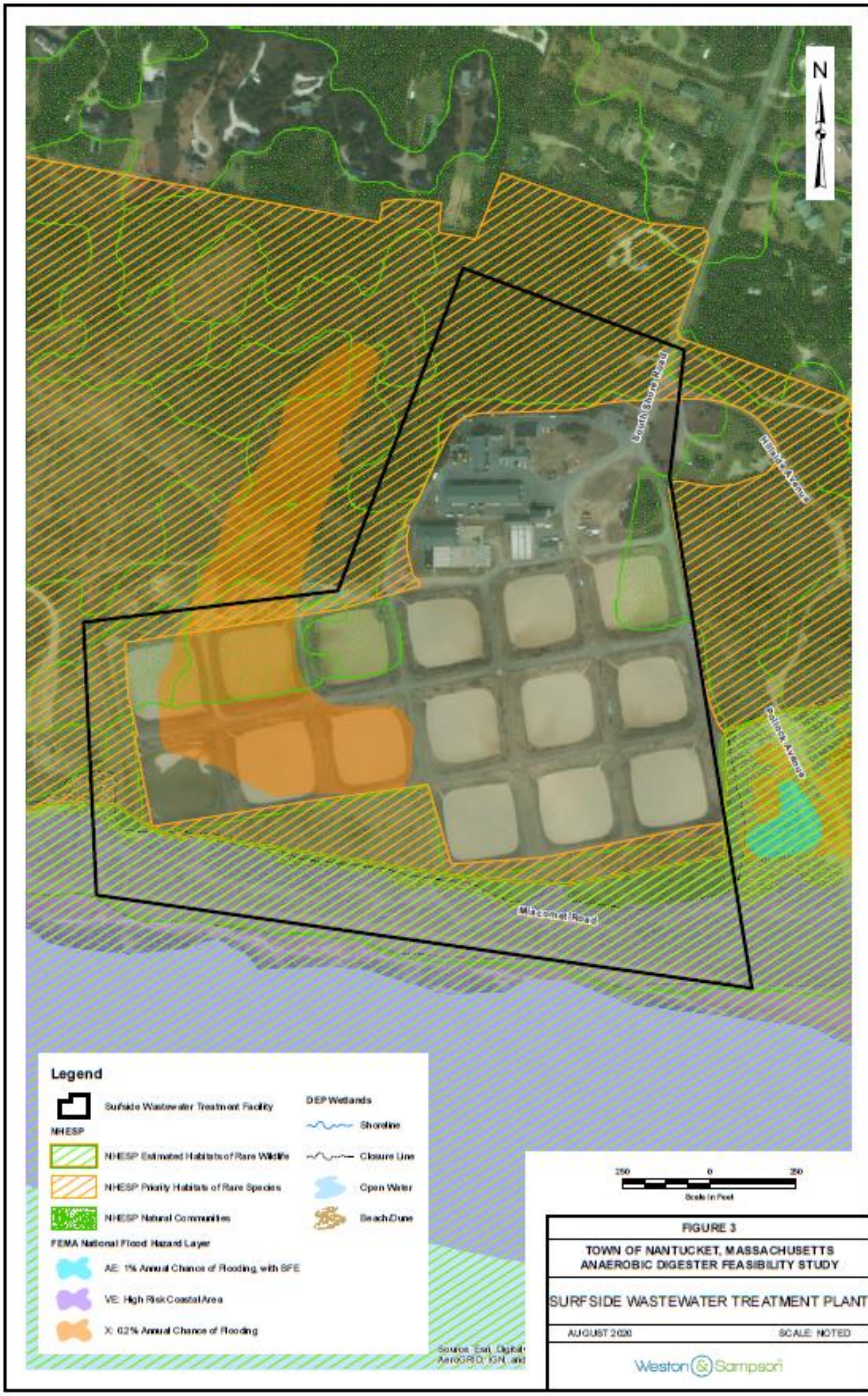

Figure 3 - Map of Environmental Hazards and Sensitive Receptors

1.3 Assessment of Existing Treatment System Operations

The Surfside WWTF was originally designed in 1987, constructed in 1991, and received significant upgrades in 2009 and 2019. The most recent groundwater discharge permit for the WWTF was issued in November 2019 and is effective for a period of five calendar years. A full copy of the groundwater discharge permit can be found in Appendix A. A summary of the permit effluent limits is included in Table 1.1 below. A brief description of the treatment system, simplified process flow schematic (Figure 4), and WWTF Plan Layout (Figure 5) follow.

Table 1.1 – Surfside WWTF Groundwater Discharge Permit Effluent Requirements			
Parameter	Frequency	Monthly Average Limit	Unit
Flow	Daily	4.0	MGD
pH	Daily	6.5 – 8.5	SU
Oil and Grease	Monthly	15	mg/L
TSS	Weekly	30	mg/L
BOD_5	Weekly	30	mg/L
Total Nitrogen	Monthly	10	mg/L
Nitrate-Nitrogen	Monthly	10	mg/L
Settleable Solids	Monthly	0.1	mg/L
Total Dissolved Solids	Monthly	1,000	mg/L
Fecal Coliform	Monthly	200	colonies/100mL

1.3.1 Headworks

Flow enters the facility through three influent lines: a 20-inch influent force main from the force main manifold (which currently combines the three force mains from the Sea Street Pump Station, Surfside Road Pump Station, South Valley Pump Station, and Monomoy South Pump Station), a force main from the in-plant pump station, and a septage discharge line. Flow proceeds through two mechanical screens and then to an aerated grit chamber. Collected grit is pumped from the sump to the Solids Handling Building to a grit classifier.

1.3.2 Septage Receiving

Septage is received at the WWTF through the septage receiving station at the primary treatment building. The septage is screened and can be either fed to the plant influent for treatment or be combined directly with waste primary and secondary sludges and processed through dewatering with only the liquid phase returned to the plant influent for treatment.

1.3.3 Primary Treatment

Effluent from the grit chamber flows via gravity to one of three primary clarifiers. Sludge removed from the primary clarifiers is stored in the primary sludge holding tanks.

1.3.4 Advanced Treatment

From the primary clarifiers, flow passes through a distribution box into two mechanically mixed anoxic basins. Effluent is pumped to three aeration basins, then flows to post-anoxic basins, and finally to one of four membrane bioreactor (MBR) basins. Waste Activated Sludge (WAS) is stored in one of two aerated sludge holding tanks (SHT) where it is mixed with primary sludge. The sludge holding tanks are periodically decanted to thicken the waste sludges with decant returned to the plant influent. Thickened sludge from the SHT is pumped to rotary presses for dewatering. Dewatered cake is hauled to the compost facility at the landfill. Further processing at the compost facility is discussed in Section 3.

1.3.5 Disinfection and Discharge

Following the MBRs, flow is directed through UV disinfection units before discharge via the groundwater discharge beds at the southern portion of the site.

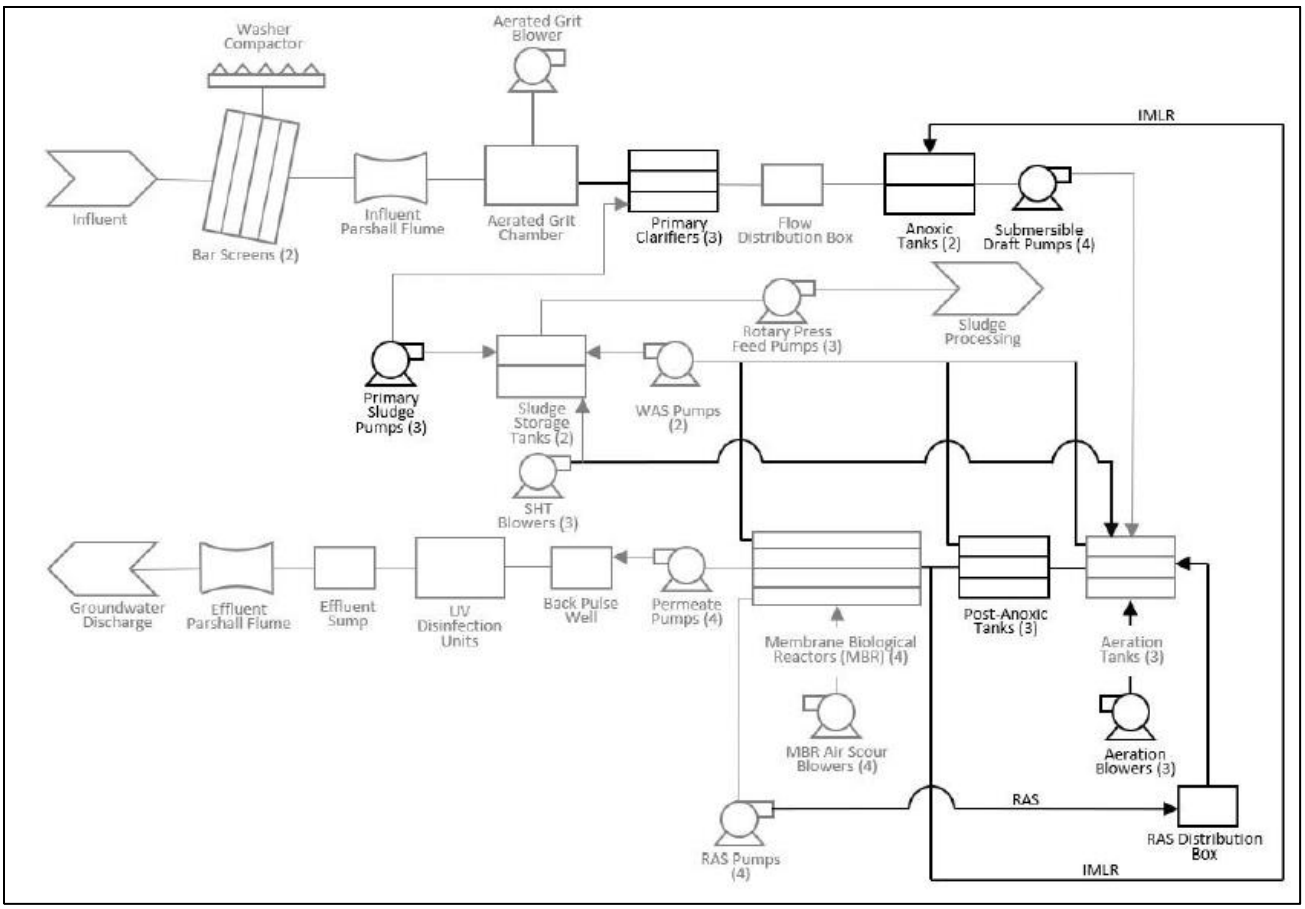

Figure 4 - Simplified Process Schematic of the Surfside WWTF

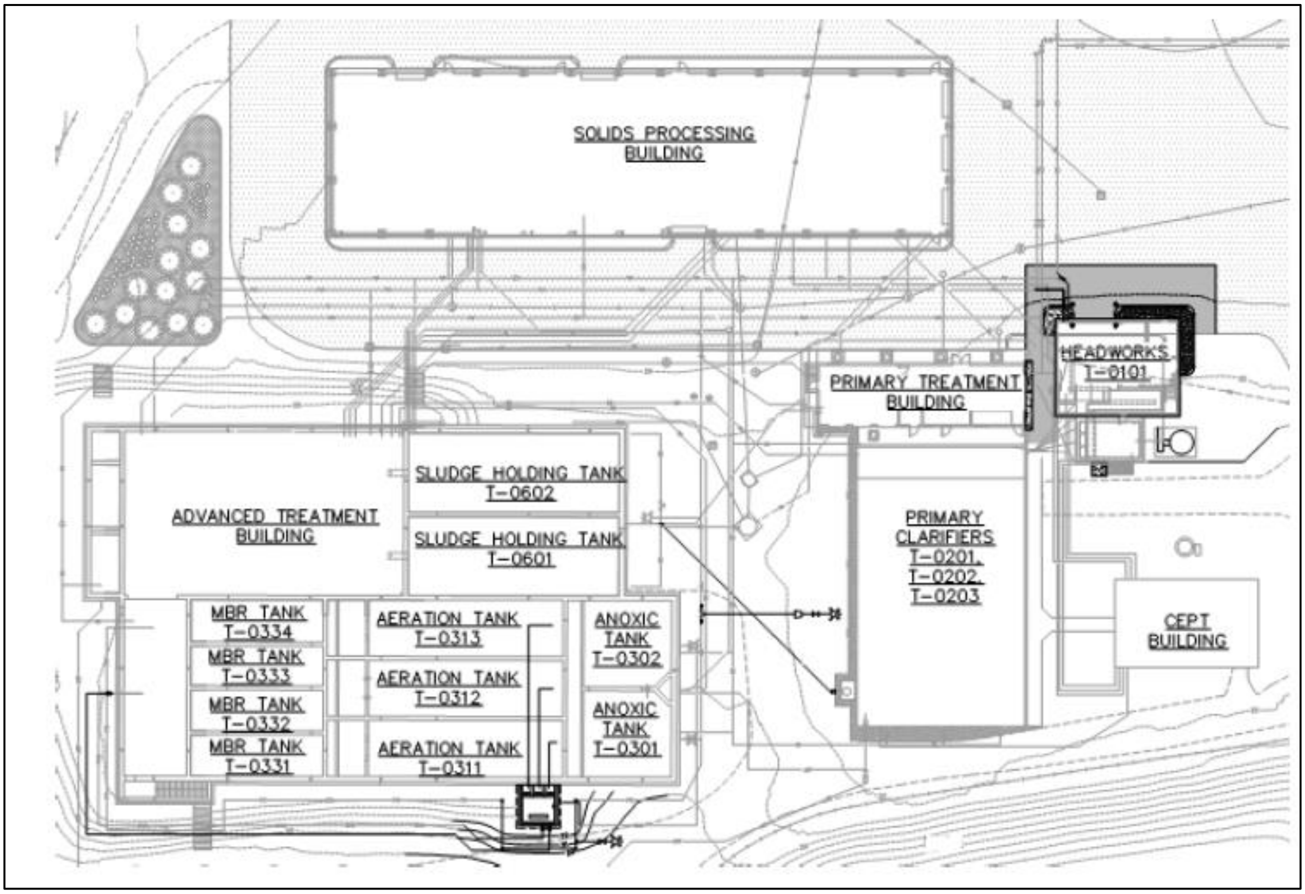

Figure 5 - Surfside WWTF Plan Layout

1.4 Existing Onsite Energy Consumption and Sludge Disposal

The Nantucket Energy Office tracks energy use on the island. In fiscal year (FY) 2019, the Town facilities and vehicles in Nantucket consumed 81,500 MMBTU, at a cost of approximately $3,226,000. Of that, 12,874,000 kWhr was electricity and 149,000 gallons was fuel oil or gasoline. Over that same time period, the Surfside WWWTF consumed 2,336,200 kWhrs of electricity, nearly 20% of the Town's total energy consumption. While there are peak and off-peak rates for the WWTF, the plant utilization does not vary significantly over the course of the day, as the facility operates 24/7, and the vast majority of the energy costs are associated with process equipment. The WWTF had similarly high fuel oil consumption, with peaks above 4000 gallons of heating oil per month in the winter. In FY 2019, sludge disposal fees for the Sewer Department were approximately $260,000.

2.0 REVIEW OF ANAEROBIC DIGESTER TECHNOLOGIES

The anaerobic digestion process in wastewater treatment and residuals management has been used predominantly to reduce the volume of sludge mass requiring disposal. The process employs bacteria, which under anaerobic conditions, consume the organic material in the sludge and convert a large fraction to gasses, predominantly methane and carbon dioxide. The methane produced from wastewater sludge digestion has been utilized as fuel to heat the digesters and in some cases to run gas fired generators, providing supplemental energy for operation of the treatment plant. However, the fuel value (i.e. gas production potential) of waste activated sludge from the aerobic treatment of wastewater, which is approximately 50% of the total waste sludge at a facility like Surfside, is relatively modest in comparison to other organic materials that have not undergone any biological treatment. Hence, conventional wastewater treatment sludge alone has not generally been viewed as a significant source of commercial energy production.

However, with increasing energy costs from traditional sources, the wastewater industry has looked for ways to enhance the energy production potential of anaerobic digestion. Supplementing the wastewater treatment sludge waste with higher energy materials has been utilized as a method to increase energy yield by boosting the methane production potential of the digester. A variety of high energy materials have been investigated and employed, including other high organic content waste streams and even raw “non waste” organic products such as corn. Some of the most economically promising sources are other high organic content waste streams, such as recovered waste cooking fats, oils and greases, dairy wastes and other industrial wastes including organic solid wastes from the food processing industry.

The anaerobic digestion process provides multiple benefits in addition to energy generation, including substantial reduction of the exiting waste stream residual mass to be disposed of and conversion of that mass to a more stable and environmentally friendly end product that can often be used as a soil amendment for agriculture. All of these factors have resulted in an increasing number of facilities employing anaerobic digestion around the world. As society’s need for renewable energy increases with advances in the efficiency of the technology, the number of anaerobic digestion facilities is expected to increase significantly in the coming years.

2.1 Anaerobic Digestion Process

2.1.1 Anaerobic Digestion Process Biology

The anaerobic digestion process is a natural “decay” process; it is a result of the natural metabolic “life cycle” of a variety of naturally occurring microorganisms and is common in nature. Many of the same microorganisms are present in the guts of animals (including humans) where they aid digestion by converting complex organics into simpler byproducts that are more easily absorbed by the body. The decay of organic sediments at the bottom of lakes and streams and in swamps is affected by anaerobic digestion and is responsible for “swamp gas,” a byproduct of the process. Anaerobic digestion, like most metabolic processes, is complex but generally includes two primary steps.

The first step is the conversion of complex organic molecules into simpler forms, ultimately to carbon dioxide, acetic acid, and hydrogen. In reality, this is a multistep process biologically carried out by several groups of microorganisms producing various intermediate byproducts that are then converted to the identified end products. Though the intermediaries may vary, the end products are largely the same. The second step is performed by a specific group of organisms know as methanogens. These microorganisms convert the acetic acid and hydrogen to methane gas, carbon dioxide, small amounts of other gases, and water. Other byproducts of anaerobic digestion, though produced in lesser amounts, include hydrogen sulfide gas, inert solids, ammonia, and others in even smaller amounts. The combined gases produced are referred to as biogas.

2.1.2 Anaerobic Digestion Process Design Overview

A well-designed anaerobic digestion facility will optimize both the potential energy value of the feed materials and the efficiency of the anaerobic digestion process. The potential energy of the feedstock depends on both its inherent energy value as well as the energy required to make it readily digestible by the microorganisms. For less homogenous feedstocks, like slaughterhouse waste and some source-separated organic wastes (i.e., organic material that has been kept segregated from other wastes from the point of generation), the materials must first be pre-processed, often mechanically degraded, screened, and blended with other wastes before they can be introduced to a digester. Fats, oils, and greases (FOG) from food production and other high strength liquid wastes, such as concentrated dairy and brewery wastes, are particularly valuable as they require relatively little pre-processing and have high energy content. A detailed discussion on pre-treatment methods is included in Section 2.3.

Once through any pre-processing, the feedstocks enter the digester vessel. Maximizing conversion of the energy available in the waste to methane requires optimization of the digestion process itself. This requires an understanding of the environmental conditions under which the microorganisms performing that conversion function best. Critical considerations for efficient digestion are temperature, pH, mixing, active biomass population and reactor organics concentration. These parameters are different for each type of anaerobic digestion process and will be discussed later in Section 2.2.1.

Methane in the biogas is a valuable product of anaerobic digestion. The biogas must be captured, stored, cleaned, and then converted to usable energy. This process requires a gas storage tank and gas scrubbing process to remove contaminants, notably hydrogen sulfide, from the gas. If not removed, these contaminants can cause corrosion, odors, and undesirable emissions during the conversion of the gas to electrical energy by gas fired engine generators. Often these systems are provided as "package plants," which combine gas scrubbing and engine generators along with all associated ancillary systems for gas treatment and engine generator operation into complete "plug and play" containerized systems. Gas storage is typically provided in variable volume storage containers or bladders. These provide for management of varying gas production and consumption rates for more efficient gas scrubbing and generator design and operation.

The liquid and solids mixture remaining after digestion is referred to as digestate, which typically requires further processing to separate the now largely biologically inert solids from the liquid phase. This is performed by conventional dewatering equipment routinely employed for undigested wastewater treatment sludges. The liquid is then discharged back to the headworks of a plant for further treatment. The solids can be applied to agricultural lands or further processed into soil amendments. If no beneficial reuse opportunity is available, the solids can be landfilled or incinerated. Conversion of organic solids by as much as sixty percent or more depending on the material, can be achieved through anaerobic digestion, significantly reducing the volume of solids requiring disposal.

2.2 Digester Design Criteria

Design of digester systems vary based on the environment and goals of the system – the most common design distinctions include operating temperature, feedstock variation, wet (low-solids) and dry (high-solids), and batch versus continuous flow. The biogas generated by the digesters needs to be stored and equalized so that it can be fed into a power generation facility evenly. Additionally, each type of digester must be well mixed to maximize the efficiency of the digestion process. This section provides a discussion of the various functional aspects of the anaerobic digestion process in general and as they relate to the specifics of an organics-to-energy project on Nantucket.

2.2.1 System Types and Requirements

As noted above, anaerobic digestion is a process which employs bacteria under anaerobic conditions to consume the organic portions of the substrates, converting most to gases, predominantly methane and carbon dioxide. The following four variables, which are discussed in greater detail later in the section, need to be considered to select the most suitable process configuration for a given application:

- Operating Temperature
- Feedstock Variation
- Wet (low-solids) and Dry (high solids)
- Batch vs. Continuous Flow

Operating Temperature

Anaerobic digestion is a multistep process, performed by different groups of microorganisms, classified by the optimum temperature ranges at which each group performs: mesophilic and thermophilic. Mesophilic microorganisms are those for which optimum growth occurs between 86°F and 100°F. Thermophilic microorganisms experience optimum growth between 122°F to 140°F.

Due to the high energy input necessary to maintain the optimal operating temperature, thermophilic anaerobic digestion is typically used when greater pathogen kill is required and a higher quality of biosolids end product, “Class A Biosolids,” is warranted for the available disposal options. The thermophilic digestion process has been shown to be highly dependent on influent substrate composition though it can produce a greater volume of biogas when the substrate feedstock is optimal. Thermophilic digestion proceeds at a higher metabolic rate and as such produces gas at a greater rate than mesophilic digestion, thereby requiring smaller overall reactor volumes. This speed however comes at the cost of increased energy required to keep the digester at the requisite temperature, which is contrary to one of the primary goals of a cogeneration project, net energy production.

There is a greater diversity of methanogen species in the mesophilic temperature range than there are in the thermophilic range. For this reason, the mesophilic species have proven to be more tolerant of variations in environmental conditions. However, they produce biogas at a slower rate than the thermophilic species, and thus require larger tankage to achieve the longer hydraulic retention time needed to achieve complete digestion. While both thermophilic and mesophilic microorganisms produce methane, the thermophilic process requires significantly more energy to maintain heat within the reactor.

Because of its greater tolerance for variations in loading and environmental conditions, as well as lower heating energy requirements, an anaerobic digestion process operating in the mesophilic range is most suitable for this project.

Feedstock Variation

Like any biological treatment process, anaerobic digestion performs best when the preferred operation conditions for the biology are achieved and maintained as consistently as possible. Digesters can be designed to process either one specific type of feedstock, which generally reduces feed content variability, or multiple feedstocks. When different feedstocks are digested together ("Co-digestion"), premixing of the feedstock to create a more homogeneous feed and storage of the mixture to allow for more continuous and uniform feed rates provide significant benefits in digester operation and performance. Co-digestion therefore requires effective planning for receiving and blending the substrates to produce a more consistent feed to the digester and consequently more optimal operation and biogas production. The digestion process for this project will be based on co-digestion of several organic feedstocks available on Nantucket to improve energy production; therefore, feedstock blending and storage provisions are included. Additional discussion regarding feedstock types, volumes, and energy values is included in Section 3.0.

Wet (low-solids) and Dry (high-solids)

Wet and dry classifications of digesters are based upon the moisture content of the feedstock. Wet digesters generally process feedstock with less than 15 percent solids and are typically in slurry form. Dry digester process feedstocks are typically 20 to 40 percent solids content which are described as "stackable." Typically, anaerobic digesters which process animal manure, WWTF sludges, SSO materials, FOG, and slurried food wastes are the wet type as these materials are low solids, high liquid content. Dry-type anaerobic digesters are typically selected for drier materials, such as yard wastes and dry animal manures. Dry-types are batch process, not as well mixed, and typically have lower methane yields than wet-type systems. Typically, large volumes of material are needed for each batch for the dry digestion to be cost-effective.

Because the majority of the identified substrate is wastewater sludge with high water content in the context of digestion and the fact that wet digestion generally provides a faster gas production rate, the wet type is most suitable for this application and will therefore be the basis of the conceptual design moving forward.

Batch versus Continuous Flow

In a batch digester, the feedstock is loaded into the digester in discrete "batches," and then remains in the vessel for set period of time while digestion takes place. When digestion concludes, the digester is emptied and reloaded. In a continuous flow digester, feedstocks are constantly and "continuously" fed into the digester and digested material is continuously removed.

Because the sources generating the substrates available on Nantucket are continuous (albeit with seasonal peaks), a continuous flow process is desirable. This allows material to be continually processed as it is generated and avoids having to store and equalize large volumes of materials in between batches. Also, less digester volume is needed as the continuous flow process has an established biomass living within the digester which self-seeds as new materials are introduced for digestion. A batch process would need to be seeded and an active biomass would need to be grown for each batch, increasing digester detention time and therefore reactor volume and facility cost.

A continuous flow digestion process is most appropriate for this project and will therefore be the basis of the conceptual design moving forward.

2.2.2 Biogas Storage Options

A biogas storage system makes a significant contribution to the efficiency and safety of an organics-to-energy facility. There are two main drivers for biogas storage: later on-site usage and for use before and/or after transportation to off-site distribution points or systems. A biogas storage system also provides equalization of variable gas production volume from the digester due to normal operational and feedstock variability and temperature changes to allow more consistent feed rates to the gas handling and cogeneration equipment for a more efficient design.

The biogas generated can be stored at low, medium, or high pressure. Medium- and high-pressure options allow for longer term storage of larger quantities of gas in a smaller space and are typically associated with commercial gas use and distribution. However, the energy, safety, and scrubbing requirements of medium- and high-pressure storage systems for biogas make them costly to build, operate, and maintain. High-pressure storage is most applicable where significant volumes of gas are generated at a site, far beyond what can be consumed at the biogas generation facility such as commercial gas production and distribution facilities. Gas production facilities would typically scrub the biogas then compress the gas for more convenient storage as a liquid (similar to propane). Medium- and high-pressure storage are not warranted for a cogeneration facility where storage is generally required to accommodate only the comparatively low, routine, short-term gas production fluctuations to allow consistency of feed rate to the cogeneration equipment, which ideally is operated continuously.

There are two broad categories of biogas storage system types: internal and external. Internal Biogas Storage Tanks are integrated into the anaerobic digester structure itself while External Biogas Holders are separate, stand-alone structures. Internal storage systems provide the simplest and least expensive storage for continuous on-site use applications such as cogeneration systems, where storage volume and pressures are modest compared to longer term storage needs for off-site commercial distribution or intermittent use. A major advantage of a digester with an internal gas storage component is the reduced capital cost of the system.

Two primary internal low-pressure storage configurations are common: floating rigid covers and flexible membrane covers within a fixed cover digester.

Rigid floating biogas holders on the digester form a low-pressure storage option for biogas systems. These systems typically operate at pressures below 2 psi. Floating gas holders can be made of steel, fiberglass, or a flexible fabric although steel is the most common. These system provide variable volume storage as they “float” on the top of the digester surface buoyed by the liquid and or the gas moving up and down with changing gas volume and pressure within the extended side walls of the digester.

The least expensive and most easily maintained gas holder is the flexible inflatable fabric top, as it does not react with the H_2S in the biogas and is integral to the digester. These types of covers are typically installed within a fixed cover digester and supported on a cable "net" installed above the digester liquid level with additional headspace above between the flexible gas cover and the rigid digester tank cover. The cover acts like a balloon or bladder that inflates and deflates corresponding to gas production and demand. Flexible membrane materials commonly used for these gas holders include high-density polyethylene (HDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), and chlorosulfonated polyethylene covered polyester. Thicknesses for cover materials typically vary from 0.5 to 2.5 millimeters. These types of gas holder covers have a much lower service life, but are also much less expensive than floating covers.

Because of the proposed application on Nantucket, gas production is anticipated to meet the energy needs for heating the digesters on site, as well as operation of a combined heat and power (CHP) electrical energy generation system. In this instance, all gas generated will be used on site, requiring that there be only enough biogas storage to provide equalization for consistent operation of the CHP process. For this reason, a low-pressure storage system is most applicable, most cost-effective, and best suited for this application.

A rubber membrane dome, although low maintenance, is subject to UV degradation over time and requires a mechanical seal to seal the cover to the tankage, instead of the simple liquid seal used with a floating gas holder. A floating gas holder is recommended which can ride up and down on the surface of the sludge in the digester. This type of system is well established, very low maintenance and provides consistent gas pressure using floatation of the cover and ballast installed beneath the cover. Therefore, a floating digester cover is anticipated for this application.

2.2.3 Digester Mixing Options

Mixing in digesters is critical for optimized digestion and gas production. Complete mixing brings the anaerobic bacteria in contact with the organic substrates, creates a homogenous mixture, and allows for consistent temperatures throughout the reactor, which is critical for the biology. Mixing methods and equipment are varied:

Mechanical Mixing

Mechanical, shaft style mixing systems include single or multiple cover-mounted vertical shaft driven mixers that extend down into the digester contents. One or more types of mixing blades are mounted onto the shaft. Rotary shaft mixers, as the name implies, are effectively propellers mounted on a shaft that rotates, providing mixing energy. Linear motion mixers employ a linear up and down shaft motion. The drive is located on the cover and the blade equipped shaft penetrates the cover into the tank contents like the rotary shaft types. The blade however is not a propeller but a specially designed open-faced disk. The shaft moves up and down a short distance and the disk creates pulsation mixing the tank contents.

Hydraulic Mixing

Pumped hydraulic systems are simple, consisting of pumps that circulate the tank contents through one or more nozzles located in the tank, directed to maximize the movement of the tank contents. The pumps are either submersibles, internal to the tank, or dry pumps, external to the tank. These systems provide mixing both thorough circulation and the jet mixing effects of the nozzles. Either “chopper” type pumps are used upstream of the nozzles, or in-line grinders. These macerate rags and other solids to prevent clogging of the nozzles. The mixing energy for such systems can be quite high in comparison to others.

Compressed Gas Mixing

A third type of system, pulsed compressed gas mixing, is considered a “non-mechanical” system in that there are no moving parts located within the reactor. Mixing is provided by a number of rising gas bubbles (or “piston” bubbles) within a large steel tube, or tubes, created by compressing some of the digester gas produced and injecting it into the in-reactor mixing equipment. There are several different proprietary mechanisms for release of the gas and creation of the pulse in the tank. This can be done by controlling the gas discharge to be intermittent or by fixed physical equipment mounted in the reactor itself. The gas mixing systems are among the lowest cost to operate and limit the potential for accumulation of debris that can occur with shaft type mixers. However, they require significant ancillary equipment including gas compressors and associated safety equipment.

The most economical and reliable system for this project is anticipated to be a linear motion mixing system. This system, mounted in the digester covers, reduces the number of piping penetrations in the digester wall, the amount of gas piping, eliminates the need for gas compressors and related gas safety equipment and has a relatively low power requirement.

2.3 Feedstock Receiving and Storage Capacity Needs

The various feedstocks (substrates) delivered to the system for co-digestion will have different handling and storage needs depending on the substrate characteristics. Source-separated organics (SSO) will typically consist largely of pre-consumer vegetable material and various packaged solid or semisolid foodstuffs. This material will also inherently contain some nondegradables such as plastic bottles, metal cans, and other packaging materials. This type of SSO is most often delivered “dry” by truck and requires additional processing to remove the undesirable materials and to “pulp” the digestible food wastes into a slurry that can then be blended with other liquid phase wastes being processed. FOG and thickened waste sludge are generally received as a more uniform slurry either by truck from offsite or directly pumped to the digester facility from an associated WWTF. These materials typically only require simple screening prior to storage and blending before they can be fed to the digester.

Feedstocks are commonly received in a designated building. This building includes a “tipping floor,” where solid wastes are dumped, and connections to separate holding tanks where liquid waste can be piped. Often, the connections provide for some screening of the liquid waste prior to storage. This receiving building would also house the mechanical equipment for pulping and separation of nondegradables from the food waste stream. Pulping and separation equipment specifics vary and the details of the different technology are beyond the scope of this discussion, but, in general, these are largely complete, self-contained type units that would sit on the operating floor within the building and be loaded with SSO by a front end loader. The units screen out nondegradables and pulp the digestible materials into a slurry that can be pumped. That pulped material is then pumped to a holding tank from which it can be fed to a blending tank with other wastes prior to being fed to the digester. Non-degradables are bagged, bailed, or otherwise collected and can potentially be recycled or are landfilled.

Receiving buildings are typically single-story, slab-on-grade construction with sufficient roof height to accommodate the trucks and other operations. They can be concrete, masonry, and/or steel construction and receive any type of architectural finishes that are appropriate for the site and visual aesthetics, as required.

To accommodate varying volumes of the feedstocks and delivery schedules, and to support consistency of the blend being fed to the digester, a series of tanks for the wet feedstocks is typically provided. These tanks can be either above or below grade and made of steel, concrete (precast or cast in place) or plastic. Each would typically be provided with a means of mixing the contents. This is routinely achieved by mechanical shaft type mixing equipment or by hydraulic or recirculating pumped mixing not unlike the digester discussed previously, albeit significantly smaller equipment. None of this pumping and mixing equipment is particularly unique and is common equipment employed at wastewater treatment facilities.

Sizing of these tanks will depend on the following factors:

- The volume of the specific substrate expected with each delivery or transfer;
- The frequency of the delivery; and
- How long this substrate will need to be stored before it can be mixed with the other substrates.

In addition to the feedstock storage tanks, a blend tank is typically provided to prepare a volume of blended/homogenized feedstock mix that can then be fed to the digester. This tank would be similar to, but generally larger than, the individual feedstock holding tanks. In cogeneration facilities constructed as this is where the primary feedstock is the WWTF waste sludge, sludge storage may already be provided, from which the sludge can be fed directly to the digester without blending or further processing or storage reducing the anaerobic digestion facility construction costs.

A discussion of anticipated feedstock (substrate) types, volumes, and generation rates is included in Section 3.0. The conceptual anaerobic digestion facility will be sized based on the availability and volume of these materials.

3.0 FEEDSTOCK ANALYSIS

As described in Section 2, feedstock composition is a major factor in determining biogas production rates and yield from an anaerobic digester and subsequent power generation capabilities. An understanding of the quantity and quality of available substrate materials is required to determine the size of the digestion facility, needed handling practices, and the amount of biogas and ultimately power that can be generated from the biogas produced.

3.1 Identification of Feedstocks

In its current configuration, the WWTF accepts and treats a variety of different waste types in addition to the typical "domestic sewage" that is received through the collection system. These additional wastes include biosolids from the Siasconset Wastewater Treatment Facility, brewery waste from Cisco Brewers, grease trap waste from local restaurants, and other liquid wastes from producers on the island. Several other waste types, including solid wastes, are produced in Nantucket and are disposed of at the island's landfill or otherwise beneficially reused. The identification of wastes for use as feedstocks for anaerobic digestion at the Surfside WWTF requires examination of all wastes produced on Nantucket, with special consideration given to those wastes which have the most beneficial physical and chemical characteristics, production volumes, and transportation requirements. Wastes which typically have high organic content, are easily transported, and can be delivered to the digester with consistency are favored for use in anaerobic digestion. A discussion of the waste types available on Nantucket follows.

3.1.1 Waste Types and Volumes

Sewage Sludge

Sewage sludge refers to the solids separated during the treatment of municipal wastewater. This sludge is a product of wastewater treatment at both WWTFs on Nantucket, Surfside and Siasconset; waste sludge from Siasconset is already transported to Surfside for solids handling. Though the volume of sludge varies with the seasonal population changes on the island, the total mass (wet) of dewatered sludge cake disposed of at the landfill is reported as approximately 1,700 tons per year and averages 26% solids for a total annual dry solids production of approximately 450 tons per year (1.23 tons per day dry solids). This compares well with estimates of sludge production based on the sum of the reported influent loads to both the Siaconcet and Surfside WWTFs and typical sludge yield of 1 lb TSS per lb of the average of the influent TSS and BOD loads.

The total volume of sludge for feed to the digesters was estimated based on a typical 60%:40% ratio of primary sludge solids to secondary sludge solids and typical primary and thickened waste activated sludge concentrations of 4% total solids (TS) and 6% TS respectively. The resulting estimated total annual amount of sewage sludge produced on Nantucket and available for use as a digester feedstock is 2,400,000 at an average TS concentration of approximately 4.6%

Fats, Oils, & Grease (FOG)

Regulations in Nantucket require the installation and maintenance of grease interceptors at all food service establishments which have a seating capacity of twenty-five seats or more, serve shallow or deep fried foods for off-site consumption, or are otherwise deemed to contribute substantial grease to the sanitary sewer. Grease traps or interceptors separate and collect FOG from sewage before it can enter the collection system. Currently the Sewer Department allows FOG waste haulers to dispose of their collected FOG at the Surfside WWTF without charge. FOG waste disposed of in this way is tracked by the Sewer Department when haulers deliver their FOG to the Surfside WWTF. Records provided by the Sewer Department indicate that approximately 8,900 gallons of FOG waste is disposed of at the Surfside WWTF annually.

However, this amount of FOG received at Surfside seems low compared to population data. Nantucket is currently updating its Rules and Regulations regarding FOG capture and disposal. However, until a new "Grease Trap Program" is implemented, there will likely continue to be significant volumes of FOG on Nantucket that will remain unaccounted for as feedstock to a digester facility. An estimate of 8,9000 gallons of available FOG was used for this feasibility study, but this number should be reevaluated in any final design.

Food Waste

Since 2014, Massachusetts has instituted a ban on the disposal of commercial organic wastes by businesses and institutions which dispose of one of more tons of this material per week. Instead such food waste is diverted to composting, conversion, recycling, or reuse operations. While organic food waste can and is often used as a feedstock for anaerobic digestion, the separation of nondegradable contaminants, such as packaging and utensils, from the food waste stream can be a challenge. The current solid waste processing operation in Nantucket would require changes in collection to optimize the use of food waste for anaerobic digestion.

Source-Separated Organics (SSO) are typically defined as compostable or digestible materials that are segregated from the point of generation and collected separately from other waste materials, to minimize the content of other, non-digestable waste materials. In the case of anaerobic digestion, SSO waste that is viable as feedstock is typically limited to food waste from high-volume commercial and institutional kitchens, grocers, and farms. This food waste includes, but is not limited to unpackaged produce, prepared food scraps, and unutilized crops. To identify the amount of total food waste and SSO material that would be potential available for anaerobic digestion, several studies were first analyzed.

In 2017, students from Worcester Polytechnic Institute (WPI) completed a study investigating the network of food assets in Nantucket (Nantucket Food Asset Map, Appendix B). The study, completed with significant input from the local food resource groups Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket, compiled a database and corresponding maps of food assets and thus food producers in Nantucket. This database, along with input from Town officials, was used to identify food producers and distributors on the island who are expected to generate a significant quantity of food waste. Figures 6 through 9 show the prevalence of large food waste generators in Nantucket.

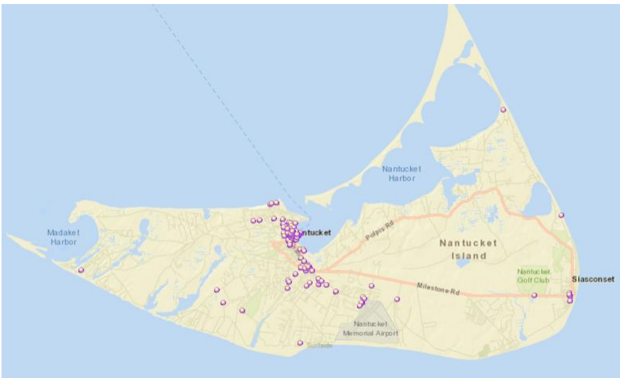

Figure 6 - Restaurants on Nantucket (2017 WPI Food Asset Map)

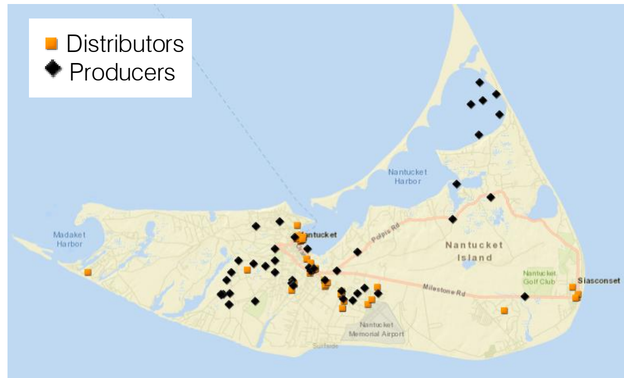

Figure 7 - Distributors and Producers (2017 WPI Food As set Map)

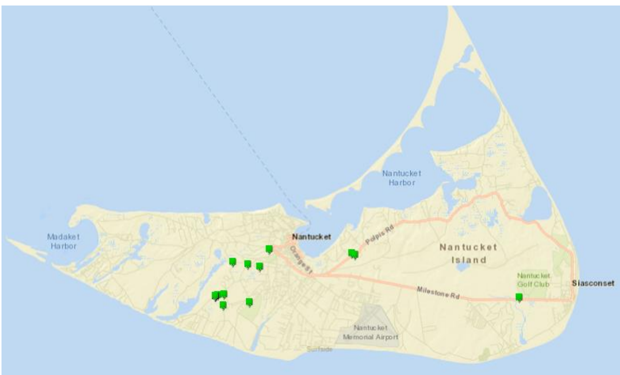

Figure 8 - Farms (2017 WPI Food Asset Map)

Figure 9 - Caterers and Commercial Kitchens (WPI Food Asset Map)

In the case of this Feasibility Study, Weston & Sampson attempted to contact numerous food waste generators in Nantucket to evaluate the volume of potential food waste from these generators as well as their willingness to divert their food waste to the anaerobic digesters being evaluated in this Feasibility Study. This effort targeted major generators, or those facilities which were generally anticipated to generate a greater daily volume of food waste per user or owner than a typical single-family household or whose waste streams could be easily diverted. This includes generators which are currently subject to Massachusetts' organic waste ban as well as several below the one ton per week threshold. Major generators of food waste include food waste processors, wholesalers, grocery stores, institutional food service providers, and large restaurants. A list of food waste generators in Nantucket are provided in Table 3.1. Though they are not specifically denoted below, Nantucket has more than fifty generators which are currently subject to state-wide organic waste ban and several more who would be included if the threshold were lowered to a half ton per week.

Table 3.1 –Food Waste Generators	
Major Generators	
Producer	Category
Cisco Brewers	Large Commercial
Stop & Shop	Large Commercial
Nantucket Public Schools	Institutional
Sherburne Commons	Institutional
Our Island Home	Institutional
Nantucket New School	Institutional
Nantucket Lighthouse School	Institutional
Nantucket Cottage Hospital	Institutional
NISDA	Institutional
Food Rescue Nantucket	Other
Sustainable Nantucket	Other/ Agricultural
Nantucket Food Pantry	Other
Bartlett's Farm	Agricultural
Moor's End Farm	Agricultural
Pumpkin Pond Farm	Agricultural
Boatyard Farm	Agricultural
Milestone Cranberry Bog	Agricultural
Windswept Cranberry Bog	Agricultural
Brant Point Shellfish Propagation Facility	Aquaculture
Offshore Animal Hospital	Other
Restaurants/Cafes (Various)	Commercial
Caterers (Various)	Commercial
Commercial Kitchens (Various)	Commercial
Grocers/ Fish Markets (Various)	Commercial
Food Trucks (Various)	Commercial
Other Generators	
Home-Owners (Various)	Residential
Maria Mitchell Association	Other

While the majority of the generators contacted expressed interest in and preliminary support for the project, none were able to provide precise volumes of food waste generated or make a commitment to diverting the food waste portion from their current waste stream; most do not currently have any source separation or contracts with SSO haulers. Therefore, Weston & Sampson instead utilized general solid waste data provided by the Department of Public Works (DPW) to estimate the quantity of Food Waste and/or SSO that could be captured for feed to the digesters. It is important to understand Nantucket's current solid waste operations in order to appreciate the limitations of the DPW data.

The significant majority of food waste in Nantucket is disposed of through the municipal solid waste (MSW) streams of residential, institutional, and commercial producers. This food waste ultimately ends up at a solid waste composting facility, "the Composter", which is owned and operated by a private company, Waste Options Nantucket LLC and is located at the Town-owned site at 188 Madaket Road, adjacent to the Town-owned landfill. The Town has a contract with Waste Options Nantucket through 2025. While the diversion of food waste from the Composter to a digester will have some impact on the operation of the composter, the degree to which the Composter operation is affected will depend on the amount of waste which can ultimately be diverted. A discussion of the current solid waste handling operations in Nantucket is presented below.

Nantucket's mandatory recycling program was established in 1996 and codified by Chapter 135 of the Nantucket Town Code. In 2019, it was amended to emphasize the separation between compostable and non-compostable wastes. Residents and businesses that self-deliver waste to 188 Madaket separate recyclables, compostable waste, and non-recyclable/non-compostable waste at the material recycling facility (MRF) and other solid wastes at adjacent drop-off facility. Figure 10 below describes the segregated waste streams at the MRF. Compostable waste is self-delivered and is described as food scraps and mixed paper.

Figure 10 - Waste Streams at the Material Recycling Facility

Waste that is collected by waste haulers is segregated into categories of glass, recyclables (mixed plastics and metals), and MSW (food wastes, paper products, and all other unsegregated waste). This definition of MSW is what is used by the DPW; for consistency, this definition will be used throughout the remainder of this report. The DPW, which runs the landfill, is in active discussions with the private haulers on the island to develop solid waste collection systems that mimic the segregation of compostable materials for self-delivered waste at the MRF. At present, approximately 75 percent of typical household waste is collected by private haulers that are regulated by the Board of Health, and 25 percent is self-delivered by residents and businesses.

In its current practice, both the MSW from haulers and compostable materials from the MRF are received at the Tipping Building and then directly enter the Composter, along with sewage sludge from the Surfside WWTF, animal manure, and invasive plant material. This material then passes through two successive screens, filtering out plastics and other residual materials larger than three-eighths of an inch across. The screen-unders are then processed through the Composter, before being made available to residents as compost.

The DPW tracks the total volume of all segregated wastes, including MSW and compostable material. Since 2018, the DPW has also begun a biannual waste sorting program to identify the constituents of its waste, particularly to parse the percentage of compostable that is delivered by haulers in MSW. Recent waste sort data indicates that compostable organics, not including paper products, could make up as much as 37% of the MSW waste stream.

However, it is important to note that not all compostable material, which includes mixed paper, is suitable for use as a feedstock for anaerobic digestion. As there is no sort data available which provides an estimate of *digestible* material (versus compostable), several assumptions were used which resulted in an estimate of 575 tons/year of SSO food waste that could be reasonably diverted from the composter to an anaerobic digester. For this calculation, the following assumptions were made, based on of historical DPW data and general industry understanding:

- an average of 11,500 tons of MSW is disposed of in the Composter annually[1]
- an average of 20% (by weight) of the MSW waste stream material is digestible, food waste suitable for the digester
- an average of 25% (by weight) of digestible food waste originates from major, food waste generators which could be reasonably diverted from the Composter to the digester[2]

[1] 11,500 tons of MSW does not include any solid waste produced by Stop & Shop, the assumed largest food waste generator in Nantucket. Currently, Stop & Shop ships all its solid waste off-island and thus has not been included in historical MSW data. The calculations used to estimate available food waste for the digester assume that Stop & Stop will continue to ship its waste off-island.

[2] As all non-recyclable, solid waste that is disposed of on the island is diverted through the Composter, all producers of organic waste subject to the state-wide organic waste ban and future proposed thresholds of this ban that could not be easily diverted to the digester would still comply with the ban.

Any diversion of food waste to the digester will require a change in the current collection and transportation of food waste. Despite a general interest in the project, many major food waste generators expressed concerns regarding the frequency and cost of additional handling needed to divert their food waste from the Composter to a digester at Surfside WWTF. These concerns particularly focused on the potential odor and increased space constraints required for segregating food wastes. Any final design of anaerobic digesters incorporating SSO food waste as a feedstock should include further evaluation of SSO food waste quantities available from individual, large, food waste generators. The current estimation of 575 tons of SSO food waste available annually is used in this feasibility evaluation based on the assumptions described above.

Other Feedstocks

Several other organic waste streams not discussed in previous sections are available as potential feedstocks. Surfside WWTF regularly receives and tracks additional waste streams which are currently added through the influent waste stream or via septage receiving. Sewer Department revenue records by waste type records indicate that the Surfside WWTF received the following average annual additional waste loads and types during the period of December 1, 2016 and December 19, 2019:

- Animal Grooming Truck Liquid Waste – 165 gal
- Residential Tight Tank Liquid Wastes – 336,000 gal
- Domestic Septage – 1,760,000 gal
- Food Truck Liquid Waste – 3,360 gal
- Equipment Cleaning WWTF Washwater – 165 gal
- Carpet Cleaner Liquid Waste – 15,100 gal
- Industrial Waste from Cisco Brewery – 133,000 gal
- Landfill Leachate – 1,900,000 gal

Two additional, organic solid waste streams are delivered to the Composter and Town landfill, Yard Waste and Animal Waste. Department of Public Works records indicate that annually the landfill receives the following quantities of these materials:

- Yard Waste – 14,000 tons
- Animal Waste – 180 tons

3.1.2 Seasonality Impacts on Feedstocks Volumes

Much like the population of Nantucket changes with the seasons, the volume of feedstocks similarly varies. Data provided by the Department of Public Works indicates that the volume (in tons per month) of MSW increases by a factor of approximately 2.4 during the peak months of June, July, August, and September. Sewer Department data indicates that municipal sewage sludge production increases by a factor of approximately 1.9 during July and August over the average monthly production for the rest of the year. The fact that the MSW increases in June and September more than the municipal sludge is likely due to the pre and post season preparations of island businesses and the associated solid waste that produces, while the wastewater production and associated human waste/wastewater load does not occur until the actual population increase occurs, generally beginning late June and ending early September. Wastewater flow data, following the direct population changes, indicate a significant increase throughout the month of June and decrease through the month of September.

While seasonal data for the FOG and Brewery Waste is not available, it is reasonable to assume that these too experience a similar seasonal variation as they are directly associated with human consumption; grease production is directly related to food preparation, and Cisco Brewery is an on-site distributor that does not export product to the mainland.

This significant seasonal shift in the quantity of the wastes has implications for the design and operation of the anaerobic digester facility being evaluated as the total digestion volume required and gas/energy production rates are directly related to the quantities of feedstock available at any one time. The impacts of this variability on the design are discussed further in Section 4.

3.2 Characteristics of Available Feedstocks

Potential feedstocks are evaluated by quality and “strength” of the substrate. In the case of anaerobic digestion, the strength of a feedstock is determined by its organic content. High strength feedstocks are desirable as they will produce a greater gas volume per volume of waste, and thus greater energy output without the need for an exceptionally large reactor volume or hydraulic residence time. Both quality and strength of a feedstock can vary. Though both are typically high strength, FOG and brewery waste historically exhibit higher variability in quality and strength. FOG strength varies with the frequency of grease trap pumping and the amount of extraneous water pumped with the grease. Brewery waste depends on production methods and housekeeping efficiency. These variabilities are, in large part, due to the fact that these wastes are derived from limited sources on an intermittent basis. Typically, food waste and sewage sludge will be more consistent in quality and strength as they are derived from routine daily human activity.

3.3 Selection of Available Feedstocks

All identified feedstocks were qualitatively evaluated for their value as a substrate in an anaerobic digester. Gas production value was considered as a function of typical expectations for the organic content strength and reported volume of available waste. A high gas production value indicates a waste load that would require lower hydraulic residence time, and therefore smaller and less expensive facility, required for comparable gas production when compared to the lower value wastes. Table 3.2 on the following page lists all identified feedstocks and their valuation criteria. Feedstocks with high gas production values were recommended as digester feedstocks and are highlighted in the table.

Table 3.2: Identification and Valuation of Potential Digester Feedstocks

Waste Name	Description	Waste Type: Solid (S), Liquid (L)	Estimated Average Annual Volume	Organic Content Strength (High, Moderate. Low)	Gas Production Potential (High, Moderate. Low)	Recommended as Feedstock? (Yes, No)
Currently Available or Received by Truck at Surfside WWTF						
FOG/ Grease Trap	Concentrated grease pumped from grease traps at restaurants and businesses preparing food	L	8,900 gal/yr	High	High	Yes
Brewery Wastes	Wastewater from the Cisco Brewery and Distillery	L	133,000 gal/yr	High	Moderate/ High	Yes
WWTF Sludge	Solids generated from Wastewater Treatment at Siasconset and Surfside WWTFs	L	2,334,000 gal/yr	High	Moderate/ High	Yes
Animal Grooming Trucks	Dilute washwater from bathing of domestic pets	L	165 gal/yr	Low	Low	No
Residential Tight Tank	Domestic wastewater captured in holding tanks where on-site septic systems are not possible and sewer service is not available.	L	336,000 gal/yr	Low	Low	No
Domestic Septage	Pumped contents of household septic tanks	L	1,760,000 gal/yr	Low	Low	No
Food Truck Waste	Wastewater from food preparation	L	3,360 gal/yr	Low	Low	No
Equipment Cleaning Plant Water	Washwater from the cleaning of equipment at the WWTF	L	165 gal/yr	Low	Low	No
Carpet Cleaner Waste	Soapy rinse water from professional carpet cleaning companies	L	15,000 gal/yr	Low	Low	No
Landfill Leachate	Liquid that percolates through a landfill and is collected at the bottom	L	1,900,000 gal/yr	Low	Low/ Moderate	No
Currently Received at Landfill						
SSO/ Food Waste	Food waste separated from residential and commercial trash received at landfill, plus SSO direct from sources (restaurants, grocers, etc.)	S	575 tons/yr	High[1]	Moderate/ High[1]	Yes[2]
Yard Waste	Grass clippings, leaves, and brush	S	14,000 tons/yr	Low	Low/ Moderate	No
Animal Waste	Manure from farm animals mixed with bedding materials	S	180 tons/yr	Low	Low/ Moderate	No

[1] Organic content is typically higher for pre-consumer sources and where household recycling is mandatory, as it is on Nantucket. Identification of pre-consumer sources and volumes is recommended.

[2] Food waste portion of MSW recommended as digester feedstock. Most easily separated (Pre-consumer) recommended for digester feed.

Four identified feedstocks were recommended:

- FOG/ Grease Trap – 8,900 gal/year
- Cisco Brewery Waste – 133,000 gal/year
- WWTF Sewage Sludge – 2,400,000 gal/year
- SSO/Food Waste – 575 tons/year

These feedstocks are integral to the conceptual design of the anaerobic digesters and are further discussed in subsequent sections.

3.4 Feedstock Pre-Treatment Needs

Pre-processing of anaerobic digester feedstock has essentially two goals: removal to the extent possible of non-degradable materials and homogenization/liquefaction. In general, the FOG/Grease Trap, WWTF Sewage Sludge, and Cisco Brewery Waste do not typically have significant non-degradable content. By contrast, MSW and self-separated compostable material, as is currently collected at the Town's Material Recycling Facility, contain other household wastes, and therefore require separation. Even source-separated organics will contain some portion of non-degradable material that must be removed prior to digester feed.

The non-readily degradable material must be separated from the true digestible food waste fraction for all feedstock streams entering the digester. In addition to separation, any food wastes must be "pulped" into a slurry for addition to the digester. Both non-degradable separation and "pulping" is achieved typically by mechanical "paddle wheel" type screening and macerating equipment. Specific equipment designs vary by manufacturer, but in general, this equipment consists of a drum screen with a set of paddles mounted on a drive shaft; the drive shaft and drum screen share a common central axis. Feed material is loaded into the drum and as the paddle wheel shaft rotates the paddles effectively beat the waste and push the material against the screen. The macerated food waste is extruded through the screen as a "pulp" while the non-degradable plastics, cardboard, and other materials exit the drum and are collected and disposed of at the landfill, or perhaps go through further separation for recycling off-site. The food "pulp" will be the consistency of a thick oatmeal that can be pumped to a holding tank where it can be mixed with the other liquid wastes to be digested, in this case, WWTF sewage sludge, FOG/ Grease Trap, and brewery waste. These three liquid waste streams have already experienced some amount of screening and are more homogenous streams.

The anaerobic digestion process is a biological degradation process performed by a variety of specific bacteria cultivated in the digester. These bacteria, as described in Section 2, perform optimally when given consistent feedstock materials. To achieve this consistency, feedstock streams are typically blended in fairly stable proportions whenever possible - particularly for those feedstocks that make up the majority of the feed. In the case of this conceptual design, the WWTF sewage sludge makes up the majority of the feed volume and will be produced daily providing reasonable consistency. Storage for Food Waste, FOG/ Grease Traps and Cisco Brewery Waste such that they can be fed into the digester over time is recommended to reduce short term load variability; these different streams can be fed into a feedstock blending tank providing load equalization during the course of the daily feed cycles.

3.5 Transportation of Feedstocks

FOG/Grease Trap and Cisco Brewery Waste are all currently hauled via truck to the Surfside WWTF and are discharged into the influent waste stream via the septage receiving station approximately six times per year and once per week, respectively. The transportation for FOG/Grease Trap and Cisco Brewery Waste to the WWTF site would remain the same, though they would need to be received at a new location within the WWTF so that they can be mixed with other feedstocks prior to entering the digesters.

In addition to the primary and secondary sludges produced by the on-site wastewater treatment processes, the Surfside WWTF also receives sludge from the smaller, Siasconset WWTF which is noted on the locus map in Figure 1 in Section 1. Sludge from the Siasconset WWTF is trucked approximately 9.6 miles to the Surfside WWTF, where it is received in the sludge holding tanks and mixed with Surfside WWTF Sludge. From there, the mixed sludge is routed through Surfside's solids handing process. No change in delivery of Siasconset WWTF sludge would be required for use of sludge as digester feedstock.

The only identified feedstock that is not already trucked into or generated at the Surfside WWTF is SSO/ Food Waste. As described in detail in Section 3.1, MSW from haulers and compostable waste from self-delivery currently are all brought to the Composter and Town Landfill at 188 Madaket Rd. which is located approximately 6.2 miles from the Surfside WWTF. The Composter and Town Landfill are identified on the locus map provided in Figure 1 in Section 1. Two options exist for the rerouting of desirable food waste to the Surfside WWTF, the proposed site for the new AD facility:

Option 1 – Truck Raw MSW and SSO/Food Waste to the Surfside WWTF

To divert raw MSW and SSO/Food Waste to the Surfside WWTF, a receiving facility would need to be constructed at the WWTF to separate and extract the digestible food waste pulp from the non-degradable fraction. This receiving facility would be enclosed in a simple slab on grade building where the raw material would be dumped and then fed into a paddle wheel separator described in Section 3.4. Non-degradable material expelled from the separator would be trucked back to the landfill for disposal with other non-degradable materials received from elsewhere in Nantucket. The food waste pulp would be stored in a holding tank which could be below a portion of the receiving building slab. Additional details of the receiving facility are discussed in Section 4.

- Option 1a: Size facility for all the MSW generated on the island
- Option 1b: Size facility for only the highest quality food waste streams

Option 2 – Add Separation and Pulping Facility to 188 Madaket Road (Landfill)

To mitigate the requirements for transporting non-degradable fractions of MSW and SSO/Food Waste pulp, an MSW separation and pulping facility at the current landfill site could be constructed. In this way, only the pulped food waste concentrate would need to be transported to the digesters at Surfside WWTF.

Assuming all MSW on the island is to be processed, Option 2 offers several potentially significant advantages over Option 1a:

- Less truck traffic to the Surfside WWTF for MSW transportation than Option 1a, though there would be a minor increase in traffic between the Landfill and the WWTF compared to current levels to transport the food waste pulp

- No change in location for the existing, raw MSW handling operation – associated odors and other environmental impacts remain unchanged at the Composter and Landfill site, which is significantly further from existing sensitive receptors than the Surfside WWTF

- No need for double trucking and handling of the non-degradable fraction of the MSW

However, it is unlikely that diverting all the food waste in Nantucket's mixed MSW to the Surfside WWTF is feasible. Rather, the best alternative is to seek out the highest quality food waste from restaurants, grocers, and other large, food waste generators. These generators would be able to separate larger volumes of food waste at the source and more easily provide for their delivery to Surfside WWTF. The cost of transporting additional MSW, the cost to pre-treat it, and the impacts to the current Composter process would be greater than the value provided by additional organic feedstock for the digester. Option 1b features a relatively small receiving facility constructed at the Surfside WWTF that would be sized only for high quality food waste streams. Therefore, our evaluation and conceptual design assumes handling of raw food waste at the Surfside WWTF only.

4.0 ANAEROBIC DIGESTION FACILITY CONCEPTUAL DESIGN

4.1 Anaerobic Digestion Conceptual Design Basis and Conceptual Layout

4.1.1 Projected Digester Loadings

Projected digester loads were calculated as a result of the feedstock analysis and selection described in Section 3 as well as generally accepted values for organic content. Table 4.1 below reiterates the projected digester feedstock loadings.

Table 4.1 – Digester Feedstock Volumes	
Feedstock	Annual Volume
FOG/ Grease Trap	8,900 gal
Cisco Brewery Waste	133,000 gal
WWTF Sewage Sludge	3,700,000 gal
SSO/Food Waste	575 tons

Impacts of Seasonal Load Variations

Nantucket is a summer tourist destination. As such, the population of the island increases significantly during the summer months. As a result of this population change, the volume of wastewater residuals at the WWTFs nearly doubles during peak season along with a similar increase in the volume of other digestible substrates. This increase is summarized in Table 4.2 which references a “Low Season” and “High Season” for substrate generation, corresponding with this population change. Based on an analysis of residuals generation at the WWTFs, high season is identified as July and August. Low season is recognized from September through June.

Table 4.2 – Seasonal Feedstock Loading Variations		
Feedstock	Daily Anticipated Volume to Digesters (gal/day)	
	High Season (July – August)	Low Season (September – June)
FOG/ Grease Trap	40	20
Cisco Brewery Waste	600	300
WWTF Sewage Sludge	11,100	5,400
SSO/Food Waste	600	250
Rounded Total	**14,000**	**6,700**

Digester Configuration

As discussed in Section 2, it is recommended that this project be based on a conventional mesophilic anaerobic digester. Redundancy of unit processes is typically a significant consideration in designing wastewater treatment systems, as it allows for both routine maintenance and emergency repair of individual units when required without losing the entire processing capacity. Other factors that impact the digester configuration and number of units include overall system size, seasonal load variations, economies of scale, system complexity, and available equipment capabilities.

The total digester volume required for this facility is relatively modest, and, therefore, it is possible that a single reactor could be sized to handle the full treatment volume with no redundancy. However, the seasonal load ratio of approximately 2:1 in Nantucket lends itself very well to a two-reactor configuration. A two-digester configuration with the full capacity of both in service designed for the summer high season loads allows one reactor to be removed from service seasonally and as needed for maintenance without loss of efficiency during the low season. During this time, a single digester could operate with the same retention time and provide the same level of digestion and efficiency of gas production per unit of substrate fed to it.

With only a single digester, the entire digestion facility will need to be taken offline every two to three years, for up to three months at a time, in order to provide the required cleaning. During this time, no gas would be produced, and the CHP unit would not be producing any electrical or heat output. All solids and substrates generated by the WWTF and the community would go directly to the composter without the benefit of capturing any of their energy value. This would also require significant adjustments to the solids handling operation and performance. While this could be done with lesser operational and energy production impacts if scheduled during the low season with a single unit, if a critical component were to fail unexpectedly during the high load season, it would put the entire facility down for repairs for potentially an extended period without any of the benefits digestion provides.

Given the seasonal variations in loading, and the other factors discussed above, it is recommended that two digesters of equal volume be constructed, each having a hydraulic retention time of thirty days at the low season loading. Based on the projected sludge and substrate volumes summarized in Section 3, this would result in two vessels of approximately 200,000 gallons each.

With this configuration, all substrates would be fed into one of the two digesters (first stage digester), which would be heated and completely mixed. This digester, during low season loadings, would have a thirty-day hydraulic retention time allowing for optimal destruction of volatile solids and thereby optimal gas production. Digestate from the first digester would then flow through an overflow line into the second digester which would not be heated or mixed. The second digester would provide some modest additional gas production as well as a clarification/settling and digestate equalization function, similar to a clarifier in a liquid stream wastewater process. Solids in the digestate would settle out allowing for both solids storage and more concentrated residual material to be pumped to the existing dewatering facilities. Residual concentrations of approximately 3% to 4% total solids are expected when digesters are configured and operated in this manner. This will greatly reduce the digestate hydraulic load on Surfside WWTF's existing sludge dewatering equipment.

During the high season, both digesters could be fed raw feedstocks and fully mixed to provide the target retention time of thirty days for optimum gas production efficiency. Alternatively, they could be operated as first and second stage digesters with raw feed to the first and overflow from the first going to the second. This is not an uncommon practice for anaerobic digestion but can reduce gas production efficiency to some degree. Therefore, for maximum efficiency the proposed configuration provides for both digesters to be operated as fully mixed reactors. However, this would eliminate the clarification settling function for digestate that would significantly enhance overall operability and performance relative to digestate handling. To address this need, the system is proposed to also include a 30,000-gallon digestate settling/storage tank to support improved dewatering operations during the high season. This may warrant further consideration as it does add some cost to the project that may not be entirely necessary; using the two stage digestion approach in summer may provide sufficient functionality and save the cost of the additional 30,000 gallon tank. If this project is pursued further, more detailed evaluation of the use of one or two digesters with or without separate digestate storage for cost efficiencies would be warranted.

An additional benefit of the two-digester configuration is increased gas storage capacity. In this operational configuration, both digesters will remain full, unless taken offline temporarily for maintenance. The recommended floating steel gasholder covers rise up and down above the liquid level in both digesters, depending upon the amount of gas produced. If gas is produced faster than can be used by the combined-heat-and-power (CHP) process, the digester covers will rise providing additional storage to meet system needs. Having a second floating digester cover not only doubles the gas storage capacity of the facility but also provides equalization of that gas so that the CHP unit can run at its optimal operating point, continuously. This provides the most consistent and efficient power and heat generation.

4.1.2 Conceptual Site Plan and Digester Facility Unit Processes

This section provides a conceptual site plan (Figures 11 and 12), a process schematic (Figure 13), and a description of each of the major elements of the proposed AD facility.

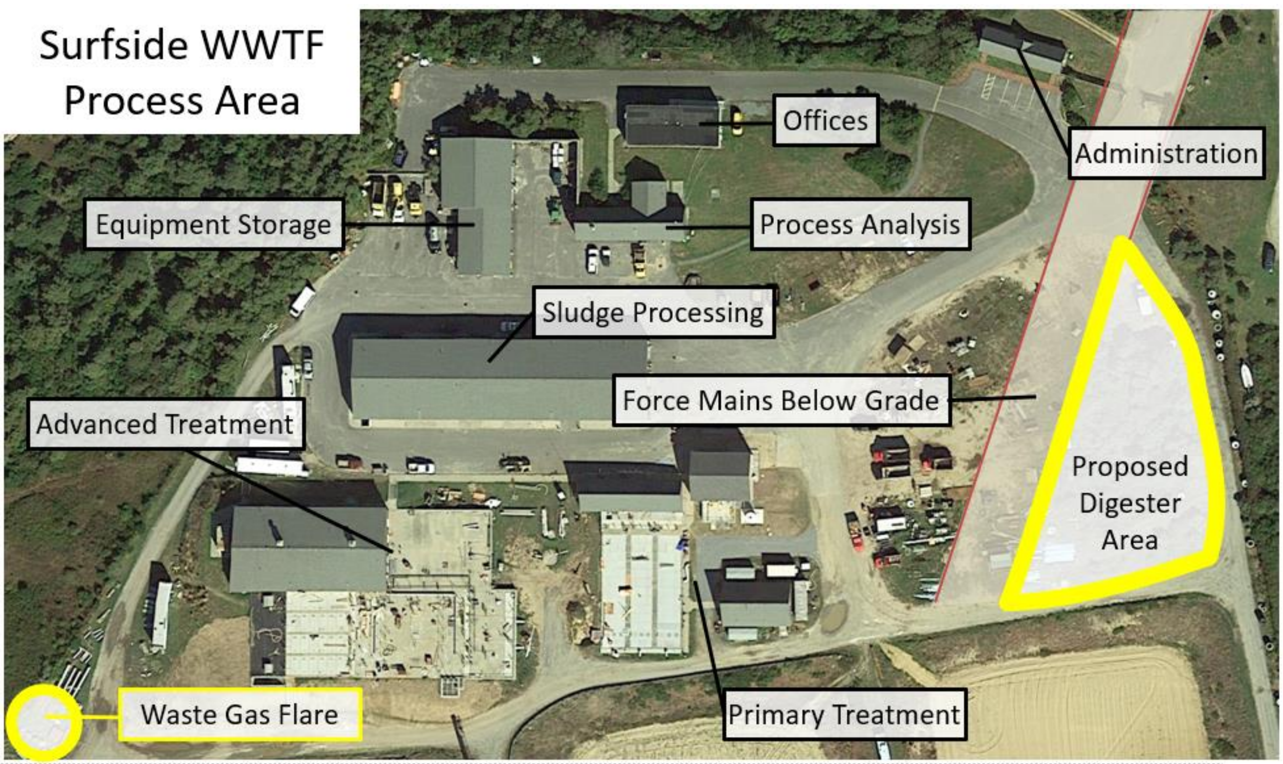

Figure 11 - Conceptual Site Plan A

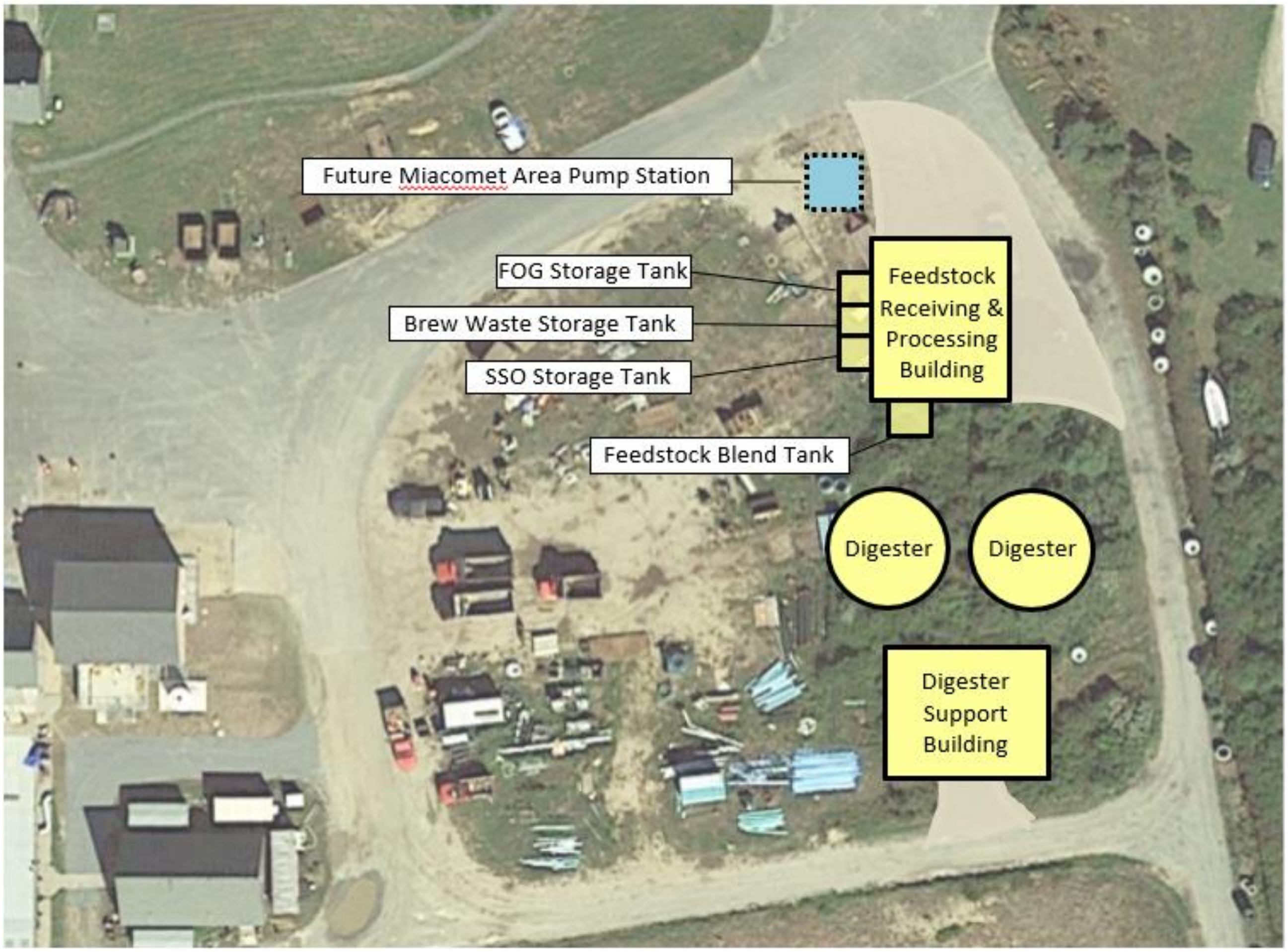

Figure 12 - Conceptual Site Plan B

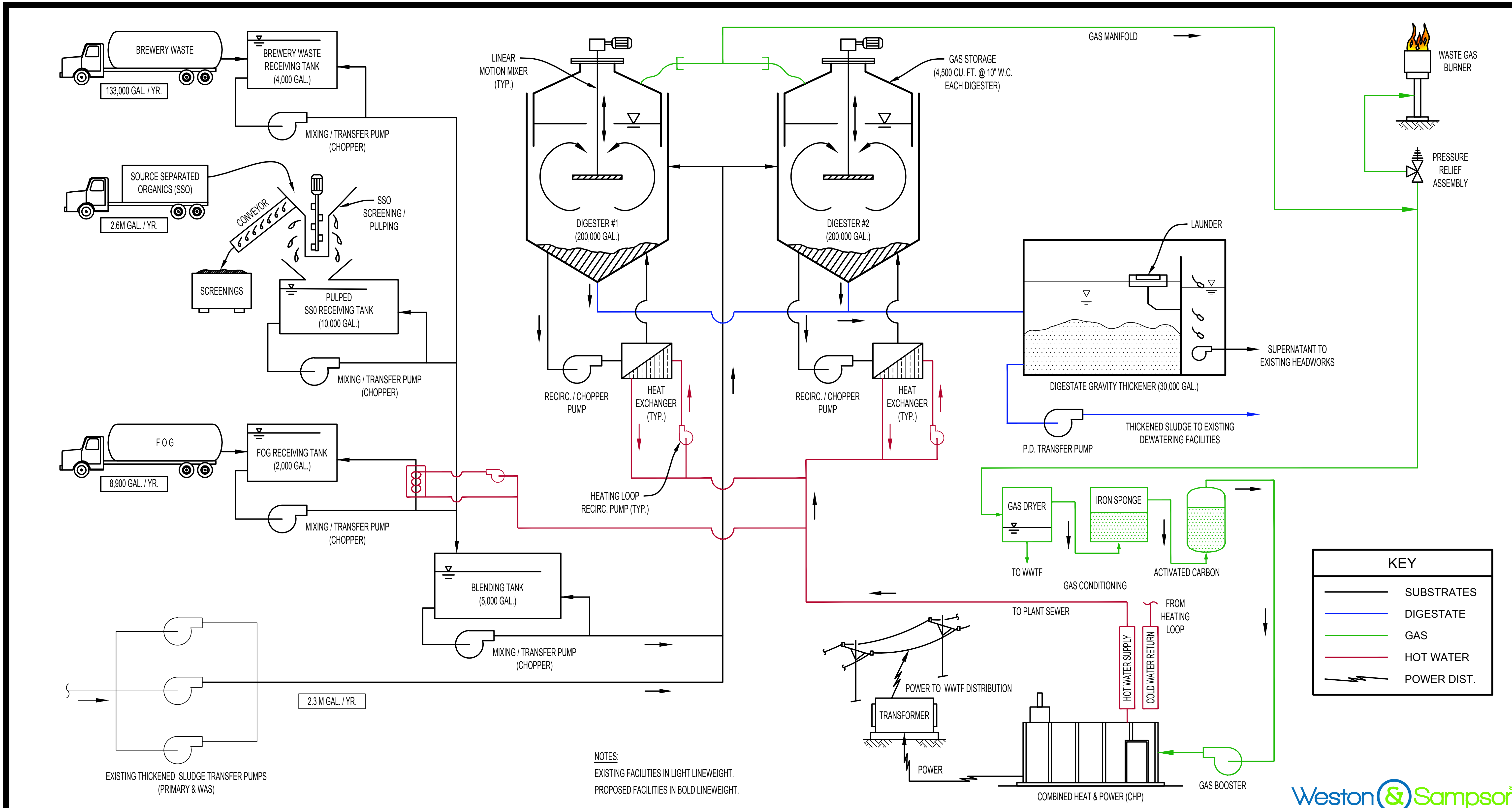

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FIGURE 13
NANTUCKET, MASSACHUSETTS
ORGANICS TO ENERGY PROJECT

ANAEROBIC DIGESTION PROCESS SCHEMATIC

SCALE: N.T.S.

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Substrate Receiving

SSO materials, brewery residuals, and FOG are expected to be delivered to the site by truck. Liquid wastewater treatment facility residuals, which are generated on site at the Surfside WWTF, will be pumped across the site to the digester complex. To facilitate receiving of these materials, which vary in water content, the construction of a “tipping” or receiving building is proposed on the east end of the site. This structure is proposed to be a masonry structure to match existing buildings, and will have a large coil door on one end, allowing trucks to enter the building and offload their materials, while odors from the delivered materials are contained.

SSO materials will be offloaded from trucks directly onto the “tipping” floor, and then transferred into a hammer mill to screen and pulp these wastes before dropping into an SSO pulp storage tank. SSO have a significant water content and once processed through the hammer mill produce a pulp typically the consistency of thick oatmeal (approximately 5-8% solids) which is pumpable with high solids handling slurry pumps. Brewery residuals will typically contain even more liquid and will also be able to be transferred between tanks via pumping. Similar tanks will be provided for FOG and for brewery residuals. The tank receiving FOG will be heated with excess heat provided by the CHP unit in order to keep the grease fluid, for ease of handling.

The FOG, Brewery waste, and SSO Pulp Storage holding tanks are anticipated to be pre-cast concrete construction with a capacity of 2,000 to 3,000 gallons. Each tank is proposed to include rail mounted submersible centrifugal chopper pumps in a vertical orientation. This allows the pumps to be removable for service without any operations staff needing to enter the tanks, which will be classified as confined spaces. The discharge from the mixing pumps will have a diverter valve, allowing substrates to be discharged back into the same tank for mixing purposes, and discharged to the next tank in the process for forward flow.

Feedstock Blend Tank

A below-slab tank for blending substrates will also be provided. In this blend, or “buffer,” tank, SSO, FOG, and brewery residuals will be mixed. The tank will be constructed of cast-in place concrete and will be largely below grade. Access to the tank can be provided outside the receiving building, for ease of maintenance. This tank is anticipated to be approximately 15,000 to 20,000 gallons in capacity and is proposed for construction on the south side of the Receiving Building. This tank will provide for feedstock blending and storage, allowing for a more consistent feed rate to the digesters for a more stable operation and gas production rate.

The buffer tank will be equipped with a jet mix type recirculation system (with a chopper pump) to maintain a homogenous mix of the multiple feed stocks, similar to the mixing pumps in the substrate receiving tanks.

Anaerobic Digestion

The homogeneous mixture of the substrates received at the Receiving Building will be pumped to one or both of the completely mixed anaerobic digesters. The target retention time of the digesters will be thirty days in order to maximize gas production and volatile solids reduction. With this retention time, the digesters will need to be approximately 200,000 gallons each. Biogas will be collected beneath a floating steel gas holder cover at the top of each digester, which is connected to the biogas system. The digester covers will be free-floating and ballasted. As gas is generated, the covers will float and rise out of the liquid to provide the gas storage volume and equalization required for consistent and optimum power production. As gas is used by the CHP system, the covers will sink back closer to the liquid level, maintaining a consistent gas storage pressure.

The digesters will have a conical bottom to facilitate sludge withdrawal and to provide a geometry within the tanks which promotes efficient mixing. The conical bottom will be constructed of cast-in-place, steel-reinforced concrete. The conical base slab will be sized to have a thickness and overall mass which will offset buoyancy, as the tank will be partially buried. The proposed digester walls will be constructed of pre-stressed concrete panels with rigid polystyrene insulation on their exterior. The tanks will be buried to approximately half of their total side water depth to help facilitate maintenance and reduce the overall visual mass/profile and insulation requirements. These tanks will be located just to the south of the proposed Receiving Building, at the existing construction stockpile area.

As noted above, residuals from the WWTF will be pumped through buried piping from the Sludge Processing Building to the digesters. WWTF residuals will not be blended with the other substrates prior to entering the digester, due to the significantly larger volume of the residuals. Instead, WWTF residuals will be pumped directly into the digesters. The digesters will be able to be operated as completely mixed or as a complete mixed first stage and unmixed second stage and sized to provide thirty days hydraulic retention time (HRT) for the combined feedstocks at maximum summer season loading conditions with both units in service. A single digester will provide a 30-day HRT during the low season. Both digesters would be maintained at their maximum liquid level allowing for the greatest hydraulic retention time and the ability to store gas beneath the floating steel gas holder covers. Having two digesters sized in this manner will facilitate operations and maintenance, as well as cleaning, as described earlier in this evaluation.

Mechanical Mixing

As noted in Section 2, mechanical mixing is recommended for the two digesters using linear motion mixers. As the name implies, these mixers employ a vertical linear shaft motion. The drive is located on the cover of the digester and the blade equipped shaft penetrates the cover into the tank contents. The linear motion mixer is designed to mix various sludge types in anaerobic digestion applications, to achieve a homogeneous mixture in tanks, while using up to 70% less power than conventional mixing systems. The mixer oscillates, producing a flow pattern that approaches nearly isotropic (uniform) mixing without the turbulence, intensity, or vortices. Due to the buoyancy of the floating steel gas holder cover, the added weight and thrust of the mixing equipment is not a concern. The cover system itself can be designed to accommodate these forces without adding significant cost to the system. The drive units for the mixers are located above the digester cover, keeping major components which require routine maintenance outside the tankage.

The mechanical mixing system will keep the contents of the digesters homogeneous and provide maximum contact between the organic materials in the substrates and the biology that is breaking them down.

Digester Heating

For mesophilic bacteria to thrive within the digesters, the liquid needs to be maintained at a minimum of 95°F. To accomplish this, digester digestate will be drawn from the bottom center of each digester by a chopper pump and circulated back to the digester through a heat exchanger. As the sludge passes through the heat exchanger it will pick up thermal energy from the cooling loop of the cogeneration unit to maintain the digester temperature at 95°F. Once the digester has reached optimal operating temperature, the heating loop for the heat exchanger will no longer call for hot water. The digester recirculation pumps when not needed for heating will be activated using a timer in the control panel. Stringy and fibrous materials in the substrates tend to recombine within the digester, which can clog the mixers and piping. By periodically operating the recirculation system, even without heat, the stream of materials will be pulled through the recirculation pump, a chopper pump, to ensure that material within the digester is macerated and homogeneous. Hot water for the digester heat exchangers will come from the heat distribution system connected to the combined-heat-and-power unit, fueled by gas produced within the digesters. Hot water will be supplied by the heat exchangers via a recovery loop from the CHP engines.

Digestate Dewatering

Digestate, the stabilized material produced by the digestion process, will be transferred via positive displacement pump back to the sludge processing building where it will be dewatered. Using the existing sludge dewatering equipment, and optimizing a liquid polymer feed system, it is anticipated that the digestate can be dewatered to approximately 22% to 26% total solids.

Filtrate will be directed back to the existing headworks of the plant. Dewatered digestate can then be used as it is currently at the composting facility as an organic substrate or mixed with soil to provide cover material at the landfill with no further treatment.

Biogas

Biogas generated by the digesters will be stored as noted above within the floating steel gas holder covers, above the liquid surface in the digesters. Gas storage is approximated at 4,500 cubic feet of gas per cover, at about 10" water column pressure. Flexible piping connections will connect the digester covers to a rigid piping system allowing gas to be conveyed to the combined heat-and-power (CHP) process for use as fuel. Gas storage and equalization will be provided by these covers to allow for a steady feed of fuel to the CHP process in spite of fluctuations in gas production throughout the day (gas production will temporarily spike after a high-value substrate is introduced to the digesters).

Gas safety equipment will be installed on all gas lines, and at all process structures to which these gas lines connect. The gas safety equipment, gas piping, and any required fire protection systems will need to be designed and installed in accordance with NFPA 820. This is the National Fire Protection Code for facilities handling biogas. Also connected to the manifold will be a waste gas burner, or flare, which will have a dedicated Liquefied Petroleum (LP) gas pilot in order to meet code. Any gas not consumed by the CHP process (e.g., if the CHP unit is off-line for maintenance) will be stored in beneath the floating gasholder covers until maximum volume and storage pressure have been reached. At that time, gas will be vented via specialized pressure relief system to the waste gas burners. The flare will ignite the vented gas, eliminating odors and any danger of explosion of the discharged gas.

Gas Conditioning

Biogas generated by the digestion process consists primarily of methane (CH_4), carbon dioxide (CO_2), and hydrogen sulfide (H_2S). In addition, the biogas is expected to contain some concentration of siloxanes, which are byproducts of soaps, surfactants, detergents, oils and pharmaceutical products that have been subject to anaerobic degradation processes. CH_4 is the fuel portion of the gas, while CO_2 is inert. H_2S can corrode engine components and siloxanes can build up within the engine causing premature wear of components. Because of these issues, conditioning of the biogas prior to its use as a fuel for the CHP is recommended.

The first step in conditioning of biogas is to remove moisture. This is achieved first by condensing moisture from the gas stream and then further drying the biogas to a low dew point. Benefits of moisture removal from the gas stream include:

- Increased CHP engine efficiency
- Prevention of corrosion
- Reduction of engine oil contamination
- Increased service life of downstream gas conditioning adsorbents (discussed below)
- Partial removal of impurities such as H2S, ammonia and siloxanes

The second gas conditioning step is removal of H_2S. As noted above, hydrogen sulfide can corrode engine components and other can corrode engine and other system components reducing service life. H_2S, when exposed to moisture, creates a weak sulfuric acid which causes the corrosion. H_2S can be removed by passing the biogas through an “iron sponge.” Commonly used in landfill gas applications, iron sponge media can consist of several different types of commercial media as well as woodchips impregnated with iron oxide. Biogas containing H_2S is passed through the media bed allowing for the reaction of a metal oxide with H_2S to form a metal sulfide that remains within the filter bed.

Siloxanes are a family of organic compounds formed by linear or cyclic chains of silicon, oxygen, and methyl groups; and are manufactured in a range of types including high and low viscosity fluids, gums, elastomers, and resins. As noted above, they are found in significant quantities in a wide and varied range of household products and pharmaceuticals. During combustion, the siloxane molecules are broken down, releasing oxygen and silicon, the latter of which combines with other elements to form abrasive silicates and other crystalline compounds. These are deposited in the combustion chamber, mainly in the upper part of the jacket, in cylinder heads and on faces of valves, abrading and wearing down the engine components.

Current siloxane removal systems use techniques that are that generally have one or two stages. Among these are subcooling adsorption on activated carbon, graphite filters and certain types of resins and washing with certain reagents. The most common of these is activated carbon adsorption, which is relatively low-tech and inexpensive. Activated carbon can be used in this application due to the relatively small size of this system and low gas flow.

All-gas conditioning equipment will be located within the proposed Digester Support Building, a 2,000 square foot slab on grade building containing equipment to support the anaerobic digestion process. This building will be located just south of the digesters.

Combined Heat and Power (CHP)

Conditioned biogas will be fed to an internal combustion engine, which will in turn drive one 150 kW generator. Power generated by the system would meet the new digester facility needs with excess that could be used to supplement existing building demands. On larger systems, excess power can be net metered for commercial distribution, providing a source of revenue to offset the construction and operating costs. In this instance, it is anticipated that all power can be consumed at the WWTF, allowing for a general reduction in commercial power purchased over the year.

Heat generated by the CHP unit will be collected in the form of hot water from the motor jacket and a heat exchanger on the generator exhaust. This water will be primarily used to supply heating for the anaerobic digesters but will also be used to offset heating costs for the two proposed buildings. Typically, up to two thirds of the energy produced by the CHP process is heat energy. We anticipate that the heat produced by the CHP will be just enough to supply the digester facility needs and supplement other onsite demands. As with the electrical power generated, we do not expect that there would be sufficient heat produced to export off-site for other commercial uses.

The CHP unit will be located on a raised pad within the Digester Support Building, along with the gas conditioning equipment.

Odor Control

It is recognized that odors from feedstock deliveries and the general digestion process could be of great concern to neighbors adjacent to the facility and along the trucking routes. The trucks delivering FOG and brewery waste feed stocks to the site will be enclosed tanker trucks. The enclosed nature of the tanker trucks will limit the potential for odor issues during transport. The SSO trucks will likely be typical sanitation trucks. At the facility, the tanker trucks will be emptied using a liquid receiving station, which will allow for direct connections to the tanker trucks via a quick connect coupling system and transfer pumps. SSO wastes received as solid material will be dumped on the tipping floor inside the Receiving building. The enclosed nature of the receiving station, receiving building, and the tanker trucks provide limited potential for nuisance odors during transport and unloading operations.

Transportation of thickened municipal WWTF residuals will be via enclosed buried piping directly to the digesters. No added odor (above existing conditions) is anticipated for this operation. On-site odor generation could be further managed and limited during the receiving, handling, and processing operations with the addition of on-site odor control measures.

Odor control provisions would be included as part of the facility design and would include development of baseline air quality data. Odorous air would be collected from non-pressurized tank headspaces as well as all process buildings via a negative air pressure ventilation system, similar to that employed at the main process tanks of the WWTF. A wet chemical scrubber system could be used to spray a chemical solution mist into the odorous air stream, oxidizing sulfides and other odor causing constituents. A biofilter system could force air upward through a media which supports the growth of microorganisms which metabolize the odor forming compounds in the air. The exact type of system will need to be selected during the facility design phase and will be based on the actual volume of tank headspace and building atmosphere to be treated.

4.1.3 Mass & Energy Balance

Mass balances are used widely in engineering and environmental analyses. To ensure that all process heat and power requirements have been accounted for, a mass and energy balance was developed. By accounting for all materials entering and leaving a system, mass flows can be identified which might have been unknown, or difficult to measure without undertaking this exercise.

The process is required for design and analysis of wastewater treatment systems as well as specific unit processes, such as anaerobic digestion, where there are many input and output variables which need to be taken into consideration. A simplified mass and energy balance based on the design and assumptions described above and in Section 4 was completed. The following process parameters used are summarized below:

- Substrate loadings
- Biogas production
- Power and heat generated by the CHP units
- Parasitic (system) heat and power requirements
- Net heat generated for WWTF use
- Waste heat produced
- Net power for WWTF use

This mass and energy balance considers all feedstock inputs, biological and mechanical conversion efficiencies to estimate outputs. The process model outputs, listed above, have been confirmed through this process and are the basis for digestion and power generation, equipment sizing and pricing; and, therefore the basis for our cost-feasibility analysis, presented later in this report.

A general mass flow diagram for an anaerobic digestion process is presented as Figure 14. The mass flow diagram would typically depict specific numerical information on the mass and energy balance for the project. A typical vendor who provides this proposed type of process equipment has indicated that the mass and energy balance for the proposed project has been completed and confirms the project, as proposed in this feasibility level analysis, to be functional. However, since the proposed process tends to be proprietary in nature and the level of analysis is not detailed design, vendors have declined to provide the specific information on our proposed project.

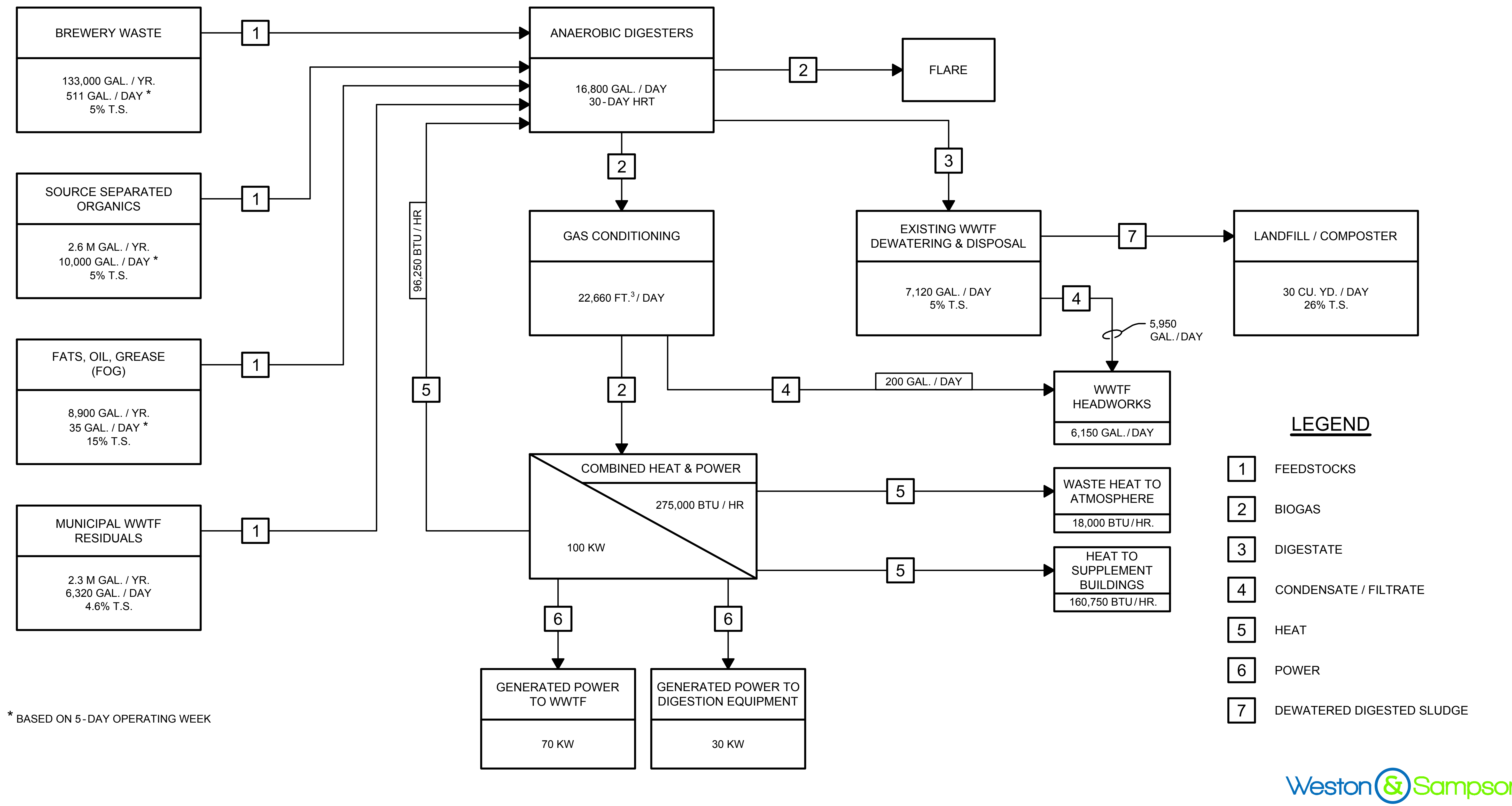

FIGURE 14
NANTUCKET, MASSACHUSETTS
ORGANICS TO ENERGY PROJECT

MASS FLOW DIAGRAM

SCALE: N.T.S.

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Rev: 1.7 Date: 08/12/2019

4.2 Impacts of Anaerobic Digestion on the Existing Wastewater Treatment Facility

While the installation of anaerobic digestion at Surfside WWTF will provide both excess heat and electricity for other uses at the site it will also have several other impacts that must be considered. This section describes these addition impacts.

4.2.1 Process Water Needs

Process water demands for the AD facility are generally limited to basic housekeeping related activities such as receiving equipment and area washdown. These needs are typically met with potable or disinfected plant recycle water. These demands are generally very minor, and the WWTF currently has a plant water system that could provide for these needs using disinfected effluent water.

SSO food waste once separated from any non-biodegradable content such as packaging materials that may be present, will produce a pumpable slurry. This material will be mixed with waste sludge from the Surfside WWTF that will have a significantly higher water content as will any oil and grease received. As such, supplemental process water for slurry production and management is not anticipated. Depending on the specific equipment employed, the initial processing equipment such as the food separation and pulping equipment could have some built in washwater required but these are typically intermittent and modest demands. The existing plant water system is expected to be sufficient to supply any such needs.

Process water needs for the AD facility are not expected to require expansion of the current plant water system at Surfside WWTF.

4.2.2 Process Sidestreams

Two process sidestreams will be generated by the AD facility: the gas phase that is scrubbed through various fixed media scrubbers and the digestate. The only return from the gas handling stream is a small amount of condensate removed from the gas before it can be used in the generator. The other fixed media scrubbing systems are essentially “dry” scrubbers. When these require media replacement that would be handled by a specialty contractor and the waste media hauled from the site.

The digestate is the primary sidestream that must be processed through the Surfside WWTF. The current solids handling approach for undigested waste primary and secondary sludge, is decant thickening in the existing sludge holding tanks with the liquid decant returned to the plant influent and the thickened sludge dewatered using rotary presses with the filtrate also returned to the plant influent for further treatment. The various impacts of the digestate return are discussed below.

Hydraulic

The plant currently dewaters the thickened sludge that under the AD project will first be sent to the digester facility. The volume of liquid returned from the dewatering of undigested vs digested waste sludge will not change significantly due to digestion. The addition of the SSO will add some return volume, however, as this is not currently processed at the facility. The anticipated increase in the liquid volume recycled to the plant influent due to the SSO addition to the digester may be significant during the high season. This added hydraulic load is not expected to require any modification of existing recycle handling systems at the plant but may require minor operational changes.

Organic

The organic content of the digestate recycle to the main wet stream will be significantly higher than the current organic load in the recycle from the processing of thickened waste sludge. The concentration of the return from the current solids handling of primary and secondary waste sludge is not routinely sampled and analyzed for organic content or other characteristics. However, typical recycle characteristics for such a stream at facilities with similar processes will have liquid phase characteristics similar to domestic sewage, while the solids concentration will be higher depending on the capture efficiency of the solids separation process. However, digestion results in a significant increase in the recycle organic and nutrient concentrations, and thus loads, over the current recycle. The typical organic concentration (measured as BOD) for the digestate which is largely soluble is approximately 1,000 mg/l compared to undigested waste sludge return of approximately 200 mg/l. This represents an increase of approximately 86 lbs/d during the high season over the current estimated return organic load. While this is significantly higher than the current recycle load, this is less than 2% of the current high season influent BOD load of approximately 4,400 lbs/d. As such, this does not represent a significant additional load to the facility.

Solids

The projected recycle solids load will be significantly reduced relative to the current recycle loads due to the destruction of solids provided in the digester, even with the additional SSO solids loads. Preliminary estimates indicate a net recycle solids load reduction of approximately 27% compared to the current condition.

Nutrients

The nutrient concentration in the recycle from solids processing of the digestate will increase compared to the current solids handling recycle. The primary nutrient of concern relative to treatment is nitrogen and more specifically ammonia nitrogen. A significant fraction of the organic nitrogen in the digester feed will be converted to ammonia nitrogen and returned to the WWTP influent. The impact of the additional ammonia load for the WWTP includes increased oxygen demand and potential for increased effluent nitrogen, which may warrant some modifications to the process and or operations. This warrants further, more detailed evaluation to ensure adequate system performance if the digester project is implemented. However, this could be mitigated through operational adjustments and minor equipment upgrades or additions if necessary.

4.2.3 Site Impacts

The impacts of the AD facility to the overall site include the elimination of the space it requires for other uses in the future, some increased runoff due to the additional hardscape, and possibly visual impacts. Given the proximity to the shore and open areas adjacent to the site, modest additional runoff is not expected to have a significant adverse impact. The footprint of the anaerobic digester facility is a small portion of the total available site which includes additional undeveloped space to support further expansion or other needs. This remaining "open space" at the site also provides visual buffer in the way of distance to nearest visual receptors. In addition, the structures for the new AD facility will not be significantly taller than those already at the site and will be constructed with appropriate visual aesthetic treatments to further mitigate any visual impact to nearby receptors.

The existing WWTF is at approximately 50% of the design capacity which includes the wastewater treatment capacity necessary at full buildout under current zoning and connection of additional existing but unsewered properties.

Given the current capacity at the plant, availability of additional space at the site, and relatively small system footprint and architectural treatments, the construction of the AD facility is not expected to have significant adverse site impacts.

4.2.4 Electrical System Inputs

The AD facility will produce both heat and electrical energy through its cogeneration system to support the heating and electrical needs of the facility, also referred to as "parasitic" loads.

The primary parasitic energy demands of the AD facility include:

- Digester Feed Waste Sludge Heating
- Digester Heating
- Digester Mixing
- Feedstock Storage Tank Mixing and Transfer Pumping
- Digestate Storage Tank Mixing and Transfer Pumping

Additional minor energy demands include:

- SSO Inorganics Separation and Pulping Equipment needs
- Gas Handling/Conditioning equipment needs
- Ancillary Building Lighting and HVAC needs

Digester feedstock and tank contents heating needs are by far the largest energy needs of the facility. The proposed system anticipates a pumped circulating loop with heat exchanger for heating; linear motion mixers are anticipated for digester mixing for their mixing and energy efficiency.

The various feedstock tanks are anticipated to be mixed using the same pumps that would be used for feedstock transfer as this also reduces the amount of equipment that would require maintenance. Feedstock tank mixing is expected to be intermittent which will reduce energy use.

The energy for pulping and SSO inorganics separation is limited to a relatively small drive motor and transfer pump which would only be in operation for a few hours per day to process the SSO received. The gas handling equipment is largely passive equipment and the ancillary building HVAC needs are very limited; the energy needs for these systems are generally within the level of error of the estimates of this conceptual level analysis.

5.0 SYSTEM OUTPUT ANALYSIS

5.1 Energy

The gas produced from the digester will be used to fuel the 150kW generator to produce electrical power and thermal energy through the required generator cooling system. Due to the seasonal variation in digester loads, which are unique to the island, and corresponding variation in gas production and generator turndown capability, two smaller generators may be advantageous. This is a detailed design issue that is beyond the scope of this feasibility analysis. The anaerobic digesters which are fed high value wastes, including primary waste sludge, SSO, and secondary waste activated sludge, will generate both heat and electricity in excess of that needed to support the heating and power requirements of the digestion system itself. The anticipated annual heat and power generation, system demands and excess of each available for other uses are summarized below.

5.1.1 Electrical and Heat Outputs

The estimated total annual methane production for the facility is estimated at approximately 5.8 million scf which at a specific energy content of 0.293 kWhr/scf and 1,000 BTU/scf for methane has a total energy content of approximately 1.7 million kWhr or 5,800 MBTUs. At a typical cogeneration electrical power conversion efficiency of 30%, the total projected annual electric energy production is estimated at 510,000 kWhr/yr.

The estimated total annual recoverable heat energy from the cogen system is approximately 2,610 MBTU/yr. A typical heat recovery efficiency expectation of 45% is assumed.

5.1.2 Parasitic Loads and Net Usable Loads

The main parasitic loads for the digester system are the digester heating and the digester and feedstock mixing and transfer equipment as discussed in Section 4.

The typical electrical energy demands associated with digester mixing, feedstock mixing, and feed equipment is approximately 30% of the total electrical energy production of the cogen system or 153,000 kWhr/yr for the proposed system. The remaining net useable energy production available for other on-site electrical uses is approximately 357,000 kWhr/yr, approximately 15% of the total annual energy consumption for the WWTF.

While the heating demands vary seasonally in northern climates, on an average annual basis, the typical digester heating requirement is 35% of the recoverable heat or approximately 910 MBTUs/yr leaving the projected net available waste heat production for the proposed facility of approximately 1,700 MBTUs/yr. Despite seasonal ambient temperature variations, supplemental digester heating is not anticipated. This analysis does not anticipate significant ancillary improvements to distribute this excess heat energy across the site.

5.2 Digestate

The waste digestate will have a significantly smaller fraction of volatile solids and at the same time a significantly higher soluble organic and nutrient content than the raw feedstock. The digestate will be dewatered onsite and the dewatered solids disposed of at the landfill/compost facility as is currently practiced for undigested waste sludge. Similarly, the liquid stream which includes both the decant from the digestate holding tank and filtrate from the dewatering presses will be returned to the Surfside WWTF influent for treatment. The projected additional loads and associated impacts of this return to the WWTF have been discussed in Section 4.2.

5.2.1 Potential Uses

While the digestion process will convert a significant portion of the particulate organics and nutrients to a soluble form, effectively removing them from the cake being disposed of at the landfill, the dewatered cake will be a relatively stable product that would be a good amendment to the composting facility at the landfill.

While separation and recovery of the nutrients in the liquid phase for use as fertilizer is technically possible at this scale, it is not expected to be cost effective to do so. Direct land application of the liquid digestate is another means of recovering the nutrient and soil conditioning benefits of the digested solids. However, because the proposed mesophilic digestion generally cannot by itself produce a product for unrestricted use without further treatment, the land application requirements are quite restrictive and not expected to be a viable option for Nantucket.

5.2.2 Disposal Needs

Disposal of the digestate as previously discussed will include dewatering on site at the Surfside WWTF with the liquid phase returned to the plant influent for treatment and the dewatered cake hauled to the composter to be composted together with other compostable waste materials. The net quantity of dewatered cake, accounting for feedstock materials in addition to wastewater sludge, will be reduced due to the digestion process by approximately 45% from the current waste sludge quantity, assuming the dewatering presses can produce a cake concentration of 26%, as is currently reported. Digestate typically dewaters as well as or better than typical undigested mixtures of primary and secondary sludge from municipal treatment and so this is a conservative assumption. As such, the capacity of the compost facility is expected to be sufficient to handle the dewatered cake.

The existing WWTF is already equipped to dewater undigested sludge and the same equipment can be used to dewater digested sludge and therefore other than the digestate storage tanks and associated transfer pumps no additional equipment for dewatering is anticipated to accommodate the proposed project.

6.0 POTENTIAL COMMUNITY IMPACTS AND MITIGATION

It is important to ensure that this project will not impose unacceptable odor, traffic, noise, or otherwise nuisance impacts on neighborhood residents and that concerns from these stakeholders are addressed. Public coordination and participation was sought throughout this feasibility effort and should remain a priority through any further phases if the Town decides to pursue the project. Maintaining meaningful and effective public participation throughout the planning process can help facilitate accurate public understanding of the project, and its likely impacts, and engage the public in implementing effective mitigation solutions wherever possible. A detailed review of public outreach efforts is included in Appendix C, and a brief review of topics of concern is presented below.

6.1 Potential Nuisance Conditions

6.1.1 Odor

Odor control is a consistent concern for any changes in operations at the WWTF. Odor control options have been considered as part of the feasibility study as described in Section 4.1 and should continue to be included in future design, including pre-processing odor control, digester covers, and digestate dewatering odor control. All treatment processes at the Surfside WWTF are currently covered with odor controls in place. From community conversations, this item does not appear to be a major concern of the public, either in current operation of the plant or for future use with an anaerobic digester facility.

6.1.2 Visibility

While the final height and volume of any proposed digesters will not be known until a final design is developed, those proposed in the conceptual design are not likely to stand out significantly from existing treatment buildings and structures at the WWTF. It is therefore not expected that the digesters would not significantly alter the visual impact of the current site facilities. The final design of additional structures at the WWTF will need to be approved by the Nantucket Historic District Commission as described in Section 7. Some concern was raised at public meeting about the size of the digesters and potential visibility. Subsequent to further discussion and clarification of the facility size, location and plan for architectural treatment consistent with the Town's visual appearance requirements, the participant's concerns appeared to be adequately addressed. Ensuring an acceptable visual aesthetic should be an integral consideration for the project.

6.1.3 Truck Traffic

Additional traffic is expected in the delivery of feedstocks, including source-separated organics, to the WWTF. However, the volume of solids needing transport from the WWTF to the composter and landfill site will decrease and offset, at least in part, any feedstock deliveries. The specific number of trips and types of vehicles will be further evaluated once feedstock availability, specifically that of source separated organics, is better known. The remaining feedstocks, sludge, FOG, and brewery waste are already delivered to the WWTF and so no increase in truck traffic related to them is anticipated. Additional discussions on transportation of feedstocks is included in Section 3.5.

7.0 ENVIRONMENTAL AND PERMITTING REVIEW

A preliminary qualitative assessment of what, if any, impact an aerobic digester project located at the Surfside WWTF would have on any nearby sensitive receptors was performed. In addition, federal, state, and local permits that may be required for the project were also considered. The development of this project would involve installation of new infrastructure at the WWTF. In general, permits may be required whenever a proposed project impacts certain environmentally sensitive resources, disturbs a specific amount of land, and/or constructs new wastewater treatment infrastructure. These are expected to include Federal, State and Local construction related approvals and permitting. Preliminary review of sensitive environmental receptors such as wetlands, endangered species and ecosystems was performed and based on the nature of the existing site and limited space required for construction special environmental permitting for construction are not anticipated. The operation of the engine generator may trigger associated air permitting. A further detailed permitting review should be conducted during later stages of project implementation.

7.1 Environmental Review

An assessment of the project site vicinity, including land abutters, hazards, and other sensitive receptors ii discussed in Section 1.2. That assessment concluded that the project outlined is not expected to have any significant impact on sensitive environmental resources as the digester facility is recommended to be located on the site of the existing Surfside WWTF.

7.2 Massachusetts State Permitting Considerations

7.2.1 General Permit for Recycling, Composting, or Anaerobic Digestion Operations

Depending on the volume and type of food waste collected at the Surfside WWTF, it is possible that the WWTF will need a General Permit for Recycling, Composting or Aerobic and Anaerobic Digestion Operations from MassDEP per 310 CMR 16.04. The threshold for the general permit of a maximum of 100 tons per day of organic material which is expected to be significantly less than what Surfside might receive.

7.2.2 Wetlands Delineation

It is not anticipated that there will be any filling of wetlands as part of this proposed project. Should the proposed project site move to a location within 100 feet of wetlands, coordination with the Nantucket Conservation Commission, including the filing of a Request for Determination of Applicability, would be required. While also not anticipated, if the project were to disturb more than 5,000 square feet of wetlands, then a US Army Corps of Engineers 404, Mass DEP 401 Water Quality Certificate, and MA Environmental Policy Act (MEPA) Environmental Notification Form (ENF) would be required.

7.2.3 National Flood Insurance Rate Mapping (FIRM)

Review of the FIRM mapping for the site indicate that the project location is not within any flood zones which would impact design.

7.2.4 MA Cultural Resource Information System (MACRIS)

A review of MACRIS should be completed to identify any potential historical or archaeological resources at the site, though this is unlikely to pose a concern as the site is on existing, previously disturbed WWTF property.

7.2.5 MEPA

MEPA regulations indicate that facilities that store, treat, or process over 50 tons of wet sludge per day may require a MEPA filing. While it is not expected based on threshold limits, the need for a MEPA filing should be determined based on the final design.

7.2.6 Air Permitting

According to 310 CMR 4.10(2), installation of new biogas fired CHP engines would require Non-Major Comprehensive Plan Approval I from MassDEP. Therefore, a Non-Major Comprehensive Plan Approval application should be submitted for this project. The Non-Major Comprehensive Plan Approval application process can take up to six months. This application must include a Best Available Control Technology analysis, and a dispersion modeling demonstration. The US EPA sets emission limits in 40 CFR 60 Subpart JJJJ, Standards of Performance for Stationary Spark Ignition Internal Combustion Engines shown in Table 7.1 below. All anaerobic digestion cogeneration engines must comply with these limits for nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOC). The New Source Performance Standards (NSPS) requirements for new spark ignition-internal combustion engine (SI-ICE) burning digester gas are divided into two parts:

1. All digester gas engines (except lean burn engines greater than or equal to 500hp, but less than 1,350hp)
2. Lean burn engines greater than or equal to 500hp but less than 1,350hp

The intention is to design the project to meet the US EPA limits identified in Table 7.1.

Table 7.1 – US EPA Emissions Standards for Stationary Digester Gas Engines								
			Emission Standards*					
Feedstock	Max. Engine Power	Manufacture Date	g/HP-hr			Ppmvd at 15% O2		
			NOx	CO	VOC	NOx	CO	VOC
Landfill/ Digester Gas (Except Lean Burn 500 ≤ HP ≤ 1,350)	HP < 500	7/1/2008	3.0	5.0	1.0	220	610	80
		1/1/2011	2.0	5.0	1.0	150	610	80
	HP > 1,350	7/1/2007	3.0	5.0	1.0	220	610	80
		7/1/2010	2.0	5.0	1.0	150	610	80
Landfill/ Digester Gas Lean Burn	500 ≤ HP ≤ 1,350	1/1/2008	3.0	5.0	1.0	220	610	80
		7/2/2010	2.0	5.0	1.0	150	610	80

* Standard: 71 Federal Register 39172, July 11, 2006

7.2.7 WP 68

As the Surfside WWTF currently operates under an existing Groundwater Discharge permit regulated by MassDEP in accordance with 314 CMR 5.00 , a "WP 68: Treatment Works Plan Approval for Groundwater Discharge and Reclaimed Water Use Facilities, without Permit Modification" application would need to be submitted to MassDEP as no modifications to the existing permit are required. An

Engineering Report which includes a detailed description of the project, design data, and sufficient technical detail is required as part of the application.

7.2.8 BWO AQ06 Notification

If the final design requires any renovation in existing buildings, like those for existing solids handling, the general contractor will need to submit a BWP AQ06 Notification Prior to Construction or Demolition to MassDEP. A hazardous materials survey of the structure would be required prior to the renovation.

7.2.9 NPDES and Stormwater

The total area of construction disturbance will be determined in final design. However, if more than one acre is disturbed by construction, an NOI for the NPDES Construction Stormwater General Permit will be required of the general contractor to be submitted to the EPA. Further, the permit requires the general contractor to implement stormwater controls and develop a Stormwater Pollution Prevention Plan (SWPPP) to minimize the amount of sediment and other pollutants associated with construction sites from being discharged into stormwater runoff.

7.3 Local Considerations

7.3.1 Historic District Commission (HDC) Certificate of Appropriateness

Nantucket goes to great lengths to maintain an aesthetic consistency to all structures in Town. As this project will result in the construction of several exterior structures, an application to the Nantucket Historic District Commission will be required.

7.4 Future Possible Considerations

In recent years, public health concerns have arisen related to a family of compounds known as per- and poly-fluoroalkyl substances (PFAS). These substances have been commonly used in a wide range of industrial and consumer products – notably in fire-fighting foams and water-proofing coatings. Because of the widespread historic use of these substances, they are now expected to be encountered in our environment. Following initial federal regulations, Massachusetts recently introduced strict drinking water standards for six PFAS compounds. The science relating to the effect and fate of these compounds is still developing.

Regulations are not yet in place related to PFAS compounds in raw wastewater, wastewater biosolids or treated effluent. However, in July 2020, EPA Region 1 and Massachusetts DEP began issuing DRAFT NPDES permits for public WWTF discharges that includes provisions for monitoring for the presence of PFAS compounds. These permit conditions are new and have yet to become fully active – due in part to the lack of an accepted test method for the compounds in wastewater and wastewater solids.

In the case of Nantucket, PFAS discharge permit provisions are not yet in place (or even issued as draft) for the Town's wastewater facilities. It may be expected that PFAS will be present to some degree in wastes when testing is conducted, and as such the Town is presently undertaking an initiative related to PFAS on the island. The information relative to these conditions is expected to develop significantly over the coming year(s).

As it relates to the consideration of an anaerobic digester at the Surfside WWTF, the PFAS is not considered to be a major driver. The anaerobic digestion process is not seen as compounding or exacerbating any issues related to these compounds; nor does the anaerobic digestion process offer significant opportunity to break down these compounds.

8.0 COST- BENEFIT ANALYSIS

Decision makers must often combine the projected design and construction costs of a project with the less easily quantifiable costs of utilizing limited resources, such as limited capacity and available energy sources (e.g. biogas from a landfill or digestion of municipal organic wastes). A final decision on whether to implement a project, therefore, must account for more than the capital cost of the project alone. When considering an infrastructure project, it is typical to complete a "cost-benefit analysis" (CBA).

CBA is often used by municipalities to appraise the desirability of proposed infrastructure improvements. It is an analysis of the expected balance of benefits and costs, including consideration of any alternatives and maintaining the status quo, or "doing nothing". Although a CBA can offer an informed estimate of the best alternative, Nantucket is advised that a perfect appraisal of all present and future costs and benefits is difficult; perfection, in economic efficiency and social welfare, is not guaranteed.

8.1 Basis of Evaluation

As described in prior sections, the feasibility of this project is compared to a baseline scenario of the current wastewater treatment and waste disposal processes in Nantucket. As a method of enhanced disposal for organic waste, including WWTF biosolids, is already in operation with the composter in Nantucket, adding an anaerobic digestion facility in addition to the existing composter represents the only alternative which was reviewed for feasibility.

Therefore for the cost-benefit analysis of this feasibility study, the costs and benefits of adding an anaerobic digestion facility at the Surfside WWTF site was compared only to the costs and benefits of the "do nothing" alternative, which would be to continue current operations with respect to biosolids disposal, composting, and landfilling. The purpose of this evaluation is to highlight the overall added benefit or cost of implementing the project described in this report compared to continuing current operations with no changes to the infrastructure.

8.1.1 Evaluation of Assumptions and Variable Definitions

Assumptions used in the development of the costs for this evaluation are as follows:

- Benefits and costs in a CBA are expressed in monetary terms and are adjusted for the time value of money; all flows of benefits and costs over time are expressed on a common basis in terms of their net present value, regardless of when they are incurred. See Appendix D for calculations.

- This analysis compares the total cost of ownership of the existing system, including the WWTF, landfill and composting operations ("do nothing" or "existing condition") to the cost of construction of the proposed anaerobic digestion system along with reduced fuel costs resulting from heat production and reduced power costs resulting from power generated by the proposed project. Also included with the proposed project will be the added value of reducing annual volumetric loadings to the existing composter.

- Implementation of the recommended improvements will have a design life of 20 years, which is the industry standard for municipal wastewater facilities, due to typical equipment longevity and possible demographic changes within the service area.

- It is assumed that this project will be funded using Massachusetts' Clean Water SRF Loan Program (CWSRF), which provides funding for Massachusetts' clean water projects in the form of low-interest loans to municipalities. Each year, Federal and State (80% and 20%, respectively) seed money is added to this program, while past project loans (repayment of funds) are being paid back. The money flowing into the State program from these three sources is then loaned back out to municipalities for more projects. For this project, it is anticipated that Nantucket would receive a discounted SRF loan rate of 1.5% for a 20-year loan, the duration of which is tied to the anticipated service life of the proposed improvements, as described above.

- A 30% project cost contingency was selected as probable project costs were determined without benefit of a final design.

- Equipment and installation costs have been developed with preliminary sizing and preliminary quotes from equipment manufacturers. As-bid costs for the equipment included in the final project, as designed, may vary as a result of economic conditions at the time of the bid, and the overall bidding climate.

- Permitting costs are not included in this evaluation.

- Gravity flow from the proposed digester complex is assumed to go to the future Miacomet Pump Station, to be constructed at the entrance to the WWTF site.

- Contractor's OH&P are included in the unit prices. Start-up and operator training are included in the listed equipment costs.

- The Digester Support Building will house the gas conditioning and CHP equipment and will need to meet the requirements of NFPA 820 for hazardous space classifications.

- Building construction is assumed to match the materials and architectural features of the buildings at the existing WWTF.

8.1.2 Net Metering Availability

Net metering, a typical consideration where power is generated from biogas, allows the owner to gain the benefit of sending any excess power back to the grid. In this scenario, the electric meter will "spin" backwards, and the utility will credit the owner's account for this production. Net metering is not a consideration for the purposes of this evaluation as the excess power estimated to be generated by the proposed project will not exceed the power requirements of the existing WWTF. The net benefit of the excess power is therefore based on the savings due to reduced consumption by the WWTF.

8.2 Baseline Scenario Economic Evaluation

In FY 2019, the debt service for the Sewer Enterprise Fund totaled approximately $3,458,000 and operating expenses totaled approximately $3,663,000. Combined, the total operating expenses and debt service for FY 2019 was $7,121,000. Operating expenses include sludge disposal and transportation costs. The Composter is privately operated, and sludge disposal fees are a part of the Sewer Enterprise Fund operating expenses. Total revenues and other financing sources in FY 2019 were $7,134,000 and $15,000, respectively.

Though a “do nothing” approach for twenty years may include a new contract with Waste Options Nantucket LLC, construction of a third electric undersea cable, and the landfill reaching capacity, estimates of future, but unknown costs associated with these events were not included in the baseline scenario.

8.3 Alternative Scenario Economic Evaluation

Simplified outlines of these costs are presented in sections below. The full cost analysis can be found in Appendix D.

The following resources were utilized for the preliminary opinion of costs:

- 2020 RS Means construction cost data
- Engineering News Record construction cost indices
- Similar recent anaerobic digester projects
- Materials and equipment costs from vendors
- Known island transportation costs
- Current labor rates and average burden for labor costs

8.3.1 Preliminary Opinion of Capital Costs

A preliminary opinion of capital costs was developed for the conceptual design presented in Section 4. A simplified outline of these costs is presented in Table 8.1 below.

Table 8.1 – Opinion of Probable Capital Costs		
Category	Approximate Cost	
	Low	High
General Conditions	$1,457,000	$1,943,000
Site Work	$814,000	$1,085,000
Concrete	$959,000	$1,278,000
Buildings	$2,759,000	$3,678,000
Process Equipment	$3,179,000	$4,238,000
Interior Finishes & Equipment	$197,000	$262,000
Controls & Implementation	$185,000	$246,000
Construction Subtotal	**$9,548,000**	**$12,730,000**
Engineering (23%)	$2,198,000	$2,930,000
Contingency (30%)	$3,524,000	$4,700,000
TOTAL	$15,300,000	$20,360,000

8.3.2 *Preliminary Opinion of Operation and Maintenance Costs*

A preliminary opinion of O&M costs was developed for the conceptual design presented in Section 4. A simplified outline of these costs is presented in Table 8.2 below. An assumption that an additional 1.5 full time staff equivalents will be required for operation of the digester facility was made.

Table 8.2 – Opinion of Probable O&M Costs		
Category	Approximate Cost	
	Low	High
Electrical	$0	$0
Heat	$0	0
Labor	$250,000	$333,000
Chemicals/ Consumables	$15,000	$20,000
Equipment O&M	$36,000	$48,000
Approx. TOTAL	**$300,000**	**$400,000**

8.3.3 *Potential Cost Savings & Revenues*

Potential operational cost savings afforded by the digester facility totals $224,000 annually, including savings in electricity, heating, and sludge disposal fees. A summary of cost savings is provided in Table 8.3 below.

Table 8.3 – Estimate of Annual Cost Savings						
Category	Electrical Energy		Heat Production		Biosolids Disposal	
	Yield (KWhr/yr)	Cost Savings	Equivalent Heating Oil (gal/yr)	Cost Savings	Volume Decrease (wet tons/yr)	Cost Savings
Sewage Sludge	241,000	$69,000	8230	$22,000	-	-
Other Feedstocks	114,000	$33,000	3870	$10,000	-	-
All Feedstocks	355,000	$102,000	12,100	$32,000	600	$90,000
Approx. TOTAL ANNUAL COST SAVINGS = $224,000						

Electrical Energy

A review of previous costs for electrical service at the Surfside WWTF indicated a reasonable, average cost per KWhr of $0.28. Based on the anticipated energy yield of the digester facility, it can be projected that in addition to what is required to run the digester facility, an additional 355,000 KWhr would be provided back to the the WWTF, resulting in an annual cost savings of $102,000/year. The data for this calculation accounted for the reduction to total and peak consumption.

Heat Production

A review of previous costs for heating oil at the Surfside WWTF indicated a reasonable, average cost per gallon of oil of $2.67. Based on the anticipated energy yield of the digester facility, it can be projected that in addition to what is required to heat the digesters, the excess heat energy available for the facility would be equivalent to approximately 12,1000 gallons of heating oil, resulting in an annual cost savings of approximately $32,000/year.

Sludge Disposal

In FY 2019, the Sewer Department spent approximately $260,000 in sludge disposal costs. The digester facility is expected to decrease the volume of sludge sent to the Composter by approximately 33% by weight. Assuming a proportionate decrease in sludge disposal costs results in an additional, annual cost savings of $90,000. Additional methods to decrease sludge volume could be employed but would require careful operational modifications and additions which could have consequences in the treatment capability and capacity of the plant. Any effort to further decrease sludge volume should be evaluated thoroughly.

Revenue

Potential revenue streams for the digester include Renewable Energy Credits, Alternative Energy Credits, and Clean Peak Energy Credits which are outlined in Section 9. Often digester facilities will gain additional revenue from tipping fees. However, the waste management program in Nantucket is unique in that most waste disposal has no associated fees. There is no fee for residential or commercial solid waste delivery to the Composter, nor is there a fee for FOG disposal at the WWTF. Thus, instituting tipping fees for this project would serve to de-incentivize disposal of feedstock wastes. For this CBA, no additional revenues, from tipping fees or energy credits, are assumed.

8.4 Economic Comparison

When comparing the baseline scenario, or "do nothing" current practice, to the proposed alternative digester facility, it is helpful to calculate the total annual cost of ownership for the digester facility. The total annual cost of ownership includes an amortized capital cost (including engineering and contingency costs) plus anticipated O&M costs. Because the amortized capital costs include the assumption of receiving a 1.5% SRF Program Loan and no other grant assistance, these approximate costs are taken to be conservative estimates. The annual cost of ownership is shown in Table 8.4 below.

Table 8.4 – Opinion of Probable Annual Costs		
	Approximate Cost	
	Low	High
Amortized Capital Project Costs	$890,000	$1,190,000
Anticipated O&M	$300,000	$400,000
Approx. TOTAL	**$1,190,000**	**$1,590,000**

Operational cost savings that are expected to be afforded by the digesters should also be included when considering the net annual financial impact of the project. The total annual financial impact of the project considering both costs and the value of savings is shown in Table 8.5.

Table 8.5 – Total Annual Economic Impact		
	Approximate Cost	
	Low	High
Annual Costs	$1,190,000	$1,590,000
Annual Savings	$224,000	$224,000
Savings-Cost Ratio	0.19	0.14

While the savings-cost ratio may be striking, it is important to note that other indirect benefits are not represented in the above CBA. The economic analysis above only takes into consideration the impact of the project on the Sewer Department's budget and capital costs. However, there are benefits of the project less easily captured. The cost for adding an anaerobic digestion facility may seem high, but it is comparatively low when considering the large, but unknown cost of adding a third under-sea electric supply cable to the island from the mainland. The intrinsic value of sustainable and renewable energy projects should not be overlooked when considering the future societal cost of climate change which will surely be felt in Nantucket.

8.5 Sensitivity Analyses

A traditional sensitivity analysis for a project such as this would look to quantify the impacts of changed inputs to the digesters, such as amounts and handling of feedstocks, and residuals management. However, Nantucket is unique in that, as an island, it cannot easily leverage the resources available from neighboring communities that mainland Towns must consider. Two major objectives for this project were to decrease the burden placed on the Town's landfill and its capacity and to utilize materials otherwise classified as wastes as a source of energy. To increase the amount of energy produced, and therefore the amount of direct economic benefit of the digester facility, would require increasing the amount and quality of feedstocks. However, this feasibility study has already addressed the reasonable, best-case scenarios for feedstock availability on the island, including SSO and FOG recovery. To increase the amount of feedstocks available to the digester, then, would require seeking substrates from off-island. Not only would the transportation costs for this be prohibitively expensive, it would also increase the total amount of materials being brought to the island for eventual disposal. While the current composter to landfill waste disposal stream mitigates the total volume of residuals requiring disposal at the landfill, it is counterproductive to the goals of this project and the Town to further consider bringing additional waste onto the island.

Other opportunities to increase the improve the economic benefit of the project include lowering the cost of operation through staffing efficiencies, collecting tipping fees for food waste, collecting Renewable, Alternative, and Clean Energy Certificates, and quantifying the direct benefits of delaying the cost for future electricity needs and an undersea cable, and delaying the costs associated with reaching capacity in the island's landfill. Many of these variables are difficult to accurately quantify within the bounds of this feasibility study. Therefore, more definitive sensitivity analyses for costs and cost recoveries are not included, though they should be considered in any later implementation stages of this project.

9.0 OWNERSHIP OPTIONS, FUNDING, AND FINANCING METHODS

9.1 Ownership Options

Three common project ownership options include a mix of publicly and privately owned and operated structures. While ownership clearly impacts the financial considerations of the project, it also affects additional risks and benefits posed to the Town. The three common ownership options which were evaluated for this project are:

- Publicly Owned and Operated
- Privately Owned and Operated
- Public/Private Partnership

9.1.1 Publicly Owned and Operated

As the title suggests, with this option the digester facility would be both owned and operated by the Town. Nearly all risks and costs will be carried by the Town, as would any revenues. As planned in the conceptual design, the anaerobic digester facility is projected to be located at and incorporated into the existing processes of the Town-owned Surfside WWTF. As such, public operation of the facility by the existing WWTF staff would result in the least disturbance to the WWTF operations and provide efficiency savings when compared to utilizing a private operator. However, the Town would need to anticipate and provide some increases in operating budget, as discussed in Section 8, to accommodate the facility.

9.1.2 Privately Owned and Operated

Opposite to a municipal option described above, a privately owned and operated facility would involve a private entity contracting with the Town to finance, own, and operate the facility under a long-term lease agreement. Under the lease agreement, the Town would typically receive a rent payment or host fee, which could, for example, be linked to the quantity of feedstocks delivered to the facility. To the extent that the Town was willing to obligate itself via long-term contract to the delivery of feedstock to the facility at a contracted disposal rate, or to the purchase of electricity generated by the facility under a power purchase or net metering arrangement, the Town could accrue benefits beyond the lease payment, such as savings on its wastewater biosolids disposal transportation costs and savings on municipal electricity costs.

Commercial entities which are often willing to enter agreements with towns in Massachusetts include integrated solid waste management companies, waste to energy companies, energy development companies, and private equity firms among others. Significant tax advantages exist for private entities to finance and own assts like the proposed facility, and public capital is disadvantaged by comparison. The impact of tax benefits on ownership of renewable energy projects can be seen by surveying the landscape of renewable energy products, where the vast majority of projects nationwide are privately owned and financed. However, as noted in section 8, many of the greatest benefits to building this facility in Nantucket are related to sustainability and environmental goals, and cost savings, though available are less immediate; the less obviously quantifiable value to the Town is greater than that to a private entity driven solely by profitability. Many of the revenue generating activities that exist for other similar projects, such as SSO and FOG tipping fees are currently offered free of charge in Nantucket. Given that much of the economic benefits are driven by savings for the Town rather than increased revenues and the limited geographic reach of the project that could provide further economies of scale and revenue generation potential, it may be difficult to find any interested private entities.

9.1.3 Public/Private Partnership

A public/private partnership option would involve financing and ownership options whereby identified risks and rewards are shared between the private entity and the Town. Risk and revenue allocation would depend upon the specifics of the agreement, but, like in the private ownership option described above, revenue generation, and therefore interest from private entities, is expected to be limited.

9.2 Funding and Financing Opportunities

A growing, nationwide interest in the reduction of waste and innovate energy generating technology has led to the increasing availability of grants opportunities and other funding sources to support the development of anaerobic digestion.

9.2.1 Grant Opportunities and Potential Revenue Streams

Several state and federal grants may be applicable to this project, though further review outside of the scope of this study is needed to determine eligibility. Potential grants are available through the Massachusetts Clean Energy Center (MassCEC), which partially funded this Feasibility Study, MassDEP, Massachusetts Department of Energy Resources (MassDOER), and the U.S. Department of Energy (DOE). A list of likely, available opportunities is included in Tables 9.1 and 9.2 below:

Table 9.1 – Grant Opportunities

Core Organization	Program	Use
MassCEC	Organics-to-Energy Program	Implementation Grant
MassDEP	Sustainable Materials Recovery Program (SMRP)	Municipal Grant for Waste Reduction and Organics Capacity Projects
	Gap Funding Grant Program	Grant for Energy Saving Projects
MassDOER	Green Communities Division	Green Communities Grant Program
USEPA	Sustainable Materials Management	Supporting Anaerobic Digestion in Communities Grant
Mass Save	CHP Incentive	Emission Credit

Table 9.2 – Potential Revenue Streams

Core Organization	Source	Designated Use
MassDEP	State Revolving Fund	Low Interest Loans
MassDOER	Net Metering[1]	Revenue
	Renewable Energy Portfolio Standard	Renewable Energy Certificates Revenue
	Alternative Energy Portfolio Standard	Alternative Energy Certificates Revenue
	Clean Peak Energy Portfolio Standard	Clean Peak Energy Certificates Revenue
BDC Capital Financing Solutions/ MassDEP	Recycling Loan Fund	Low Interest Loan

[1]Net Metering is not anticipated for this project as it is presented in the conceptual design. Should there be significant changes to the design, net metering should be reconsidered.

10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

This feasibility study highlights the complexities of waste disposal on Nantucket and provides a path forward for constructing a digester facility in Nantucket. Several evaluation criteria were considered throughout this study and are critical in understanding the feasibility of this project. Conclusions about this project are presented related to these identified evaluation criteria as follows:

- Capital and O&M Costs – Costs for implementing the anaerobic digester facility are not insignificant. The opinion of probable capital costs ranges in magnitude from $15,000,000 to $20,000,000, and annual O&M costs range from $300,000 to $400,000. A sizeable majority of the O&M costs are driven by a conservative increase in the amount of labor required at the Surfside WWTF. While the existing staff consistently strives for efficiencies in labor and operations, it is possible that a concerted effort to increase efficiencies could mitigate the need for additional staff. A fully public ownership option is the most appropriate, though low interest loans and grant opportunities are available and could decrease the burden on tax-payers and sewer users in Nantucket.

- Cost Saving & Revenue Generation – There is opportunity for the anaerobic digester facility to provide cost savings and revenue generation for the Sewer Department. Cost savings driven by a reduction in electricity use, heating oil, and biosolids disposal fees are anticipated to total approximately $90,000 annually. Though tipping fees are unlikely to be appropriate for Nantucket, Renewable and Alternative Energy Certificates offer another promising source of potential revenue.

- Energy Independence for the Island – Nantucket is unique in that, as an island, it cannot as easily rely on neighboring towns and existing infrastructure in the Commonwealth to provide resources such as electricity. The Town receives the majority of its electricity through two undersea cables which stretch across the ocean floor from the mainland. The Town has embraced energy independence as a critical priority; its energy office has led several ambitious renewable energy initiatives such as solar and wind projects and in 2019 was recognized as a Green Community by the MA Department of Energy Resources. Sewage sludge and other organic materials represent an untapped source of energy on the island to be exploited. The anaerobic digester facility presents another opportunity for the Nantucket to lead the way in utilizing renewable energy to further postpone the need for a costly, third undersea cable.

- Landfill Capacity Burden and Impacts to Composter Operations – Much like the energy challenges Nantucket faces as an island, solid waste challenges and space limitations are a major concern that the Town is prioritizing. The landfill on Nantucket has a finite capacity and so every opportunity to limit waste should be pursued. Through regulatory changes about solid waste and strong public outreach campaigns, the Town has succeeded in reshaping the way it thinks about and handles solid waste, but challenges remain. The current solids waste process sends nearly all of Nantucket's organic waste through a composter before being able to utilize the composter residuals for landscaping and reuse around the island. While the reduction of biosolids from Surface WWTF wouldn't currently impact the volume of waste sent to the landfill, there are uncertainties about the future of the composter and capacity of the landfill – every opportunity to reduce the volume of solid waste on the island should be considered.

- WWTF Site and Operational Impacts – With room to spare on site, the construction of a digester facility at the Surfside WWTF does not present any major operational challenges beyond the addition of a new process. Physically, there is room on-site for the presented conceptual design, whose most significant construction includes two small buildings, four small underground storage tanks, and two digesters which are partially below grade as well. Though further details would be clarified during final design, modifications of existing yard piping and treatment processes are limited.

- Ammonia Loading – The addition of an anaerobic digester to the existing facility will increase the influent ammonia load as anaerobic digestion will convert the particulate organic nitrogen in the sludge solids to soluble ammonia. This liquid phase ammonia in the digestate will be returned to the WWTF influent from the dewatering system. This warrants further analysis to assess the possible impacts to the WWTF processes and/or operations to ensure adequate treatment is maintained.

- Sensitive Environmental Receptors – As the proposed location for the digester facility is within the existing bounds of the current Surfside WWTF, impacts to environmental receptors are limited. Abutters are limited and the nearest private residence is more than 500 feet from the WWTF. There are no Areas of Critical Environmental concerns, flood plains, priority habitat, or designated wetlands on-site. Avoiding sensitive receptors and hazard areas is uncomplicated for the proposed siting.

- Impacts to the Neighborhood – Again, because the siting is at an existing, operational WWTF, there is unlikely to be any increase in nuisance conditions to the site. Odor control is already in place on-site and has been accounted for in the conceptual design. There is the possibility of increased traffic due to the tipping of SSO material, but it is not believed to be a significant increase and would be offset to some degree by the reduced waste sludge trucking traffic. Other than traffic, no increase in noise is anticipated, nor any aesthetic issue as the design will follow Historic District construction requirements and blend in with the rest of the Surfside WWTF.

- Environmental Stewardship – There is intrinsic value to the support and development on environmentally beneficial and renewable energy projects for a community. The energy savings, through the use of a currently untapped energy source, provide greater benefits than can be easily quantified by an analysis of direct costs alone. Such a project would support the Environmental Leadership focus area of the Select Board's 2018 Strategic Plan. Quantifying environmental benefits, like those for greenhouse gas reduction, and life cycle costs would require detailed investigation.

Though there are challenges to implementing the proposed project, chiefly financial, there are clear and multiple benefits for the Town. The construction and operation of an anaerobic digester facility at the Surfside WWTF is technically feasible and economically possible if there is the support for funding.

10.2 Recommendations and Next Steps

Recommended next steps include continued and additional project development to further consider the economics of building and operating an anaerobic digester facility at the Surfside WWTF. The additional project development includes:

- Further review and additional discussions with state and federal agencies regarding the potential for additional grants for an anaerobic digester on Nantucket.
- Further review of potential Renewable, Alternative, and Clean Peak Energy Certificates available for Nantucket.
- Further discussions with large SSO producers on the island to develop relationships and get commitments to ensure additional feedstock to the digester.
- Further review and implementation of a plan to get more FOG into the digester. Based on records from the Sewer Department, only 8,900 gallons per year are trucked to the WWTF. The Town is currently updating the FOG regulations for restaurants and food service establishments. However, without enforcement of the regulations to require the installation and maintenance (including routine pump out and cleaning), this will remain an issue for the Sewer Department. The town would also benefit from a system to acquire grease directly from homeowners, including those on both town sewer and private septic systems. Much of the grease from homes on private septic systems likely ends up in the trash.
- The Town does not currently charge tipping fees for solid waste disposal at the landfill or FOG disposal at the WWTF. Additional consideration for the implementation of a system of tipping fees could encourage disposal of certain feedstocks to the digester as opposed to the landfill.
- Further consideration of the economics of the digester project along with the value of related issues such as limited landfill capacity, energy independence, and environmental stewardship.

APPENDIX A

2019 Individual Groundwater Discharge Permit

MassDEP

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

November 19, 2019

Mr. David Gray, Director
Nantucket Sewer Department
81 South Shore Road
Nantucket, Massachusetts 02554

RE: NANTUCKET – Surfside Wastewater Treatment Facility, 81 South Shore Road.
Transmittal No. X259157
Permit No. 200-3

Dear Mr. Gray:

In response to your application for a permit to discharge into the ground treated effluent from the Old Chatham Road RV Resort and after due public notice, I hereby issue the attached final permit.

MassDEP received comments on the permit during the public comment period; therefore, in accordance with 314 CMR 2.08, the permit becomes effective thirty (30) days after issuance.

Parties aggrieved by the issuance of this permit are hereby advised of their right to request an Adjudicatory Hearing under the provisions of Chapter 30A of the Massachusetts General Laws and 314 CMR 1.00, Rules for the Conduct of Adjudicatory Proceedings. Unless the person requesting the adjudicatory hearing requests and is granted a stay of the terms and conditions of the permit, the permit shall remain fully effective.

Should you have any questions regarding this matter, please contact me at (508) 946-2814

Sincerely,

Brian A. Dudley, Section Chief
Wastewater Management – Cape and Islands

D/BAD/
Enclosures

ecc: Ms. C. Elizabeth Gibson, Town Manager
16 Broad Street
Nantucket, MA 02554
(with enclosures)

Mr. Roberto Santamaria, Director
Nantucket Health Department
3 Chestnut Street
Nantucket, MA 02554
(with enclosures)

DEP/Boston
Attn: Marybeth Chubb
(with enclosures)

DEP/SERO
Attn: Lisa Ramos
(with enclosures)

MassDEP

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Southeast Regional Office • 20 Riverside Drive, Lakeville MA 02347 • 508-946-2700

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

INDIVIDUAL GROUNDWATER DISCHARGE PERMIT

Name and Address of Applicant: Town of Nantucket (Sewer Department), 81 South Shore Road, Nantucket, MA 02554

Date of Application: January 23, 2014

Application/Permit No. 200-3

Date of Issuance: November 19, 2019

Date of Expiration: December 19, 2024

Effective Date: December 19, 2019

AUTHORITY FOR ISSUANCE

Pursuant to authority granted by Chapter 21, Sections 26-53 of the Massachusetts General Laws, as amended, 314 CMR 2.00, and 314 CMR 5.00, the Massachusetts Department of Environmental Protection (the Department or MassDEP) hereby issues the following permit to: Town of Nantucket (Department of Public works) (hereinafter called "the permittee") authorizing discharges to the ground from the municipal Surfside Wastewater Treatment Facility located at South Shore Rd., Nantucket, MA 02554 such authorization being expressly conditional on compliance by the permittee with all terms and conditions of the permit hereinafter set forth.

Brian A. Dudley

NOVEMBER 19, 2019
Date

I. SPECIAL CONDITIONS

A. Effluent Limits

1) The permittee is authorized to discharge into the ground from the wastewater treatment facility for which this permit is issued a treated effluent whose characteristics within one month of startup and continuing thereafter shall not exceed the following values:

Effluent Characteristics	Discharge Limitations
Flow	4.0 million gallons per day (MGD)
Oil and grease	15 mg/l
Total Suspended Solids (TSS)	30 mg/l
Total Nitrogen ($NO_2 + NO_3$ + TKN)	10 mg/l
Nitrate-Nitrogen	10 mg/l
Biochemical Oxygen Demand, 5-day @20°C (BOD_5)	30 mg/l
Settleable Solids	0.1 ml/l
Total Dissolved Solids	1000 mg/l
Fecal Coliform	200 colonies/100mL

a) The pH of the effluent shall not be less than 6.5 nor greater than 8.5 at any time or not more than 0.2 standard units outside the naturally occurring range.

b) The discharge of the effluent shall not result in any demonstrable adverse effect on the groundwater or violate any water quality standards that have been promulgated.

c) The monthly average concentration of BOD and TSS in the discharge shall not exceed 15 percent of the monthly average concentrations of BOD and TSS in the influent into the permittee's wastewater treatment facility.

d) When the average annual flow exceeds 80 percent of the permitted flow limitations, the permittee shall submit a report to the Department describing what steps the permittee will take in order to remain in compliance with the permit limitations and conditions, inclusive of the flow limitations established in this permit.

B. Monitoring and Reporting

1) The permittee shall monitor and record the quality of the **influent** and the quality and quantity of the **effluent** prior to discharge to the leaching facilities according to the following schedule and other provisions:

INFLUENT:

Parameter	Minimum Frequency of Analysis	Sample Type
pH	Daily	Grab
BOD_5	Weekly	24-Hour Composite
Total Suspended Solids	Weekly	24-Hour Composite
Ammonia Nitrogen	Weekly	24-Hour Composite

EFFLUENT:

Parameter	Minimum Frequency of Analysis	Sample Type
Flow	Daily	Meter reading Report: Min – Max - Average
pH	Daily	Grab
UV Intensity	Daily	Continuous
Total Suspended Solids	Weekly	24-Hour Composite
Total Dissolved Solids	Monthly	24-Hour Composite
Oil & Grease	Monthly	Grab
BOD_5	Weekly	24-Hour Composite
Nitrate Nitrogen	Monthly	24-Hour Composite
Nitrite Nitrogen	Monthly	24-Hour Composite
Total Kjeldahl Nitrogen (TKN)	Monthly	24-Hour Composite
Total Nitrogen ($NO_2 + NO_3 +$ TKN)	Monthly	Calculated
Fecal Coliform	Monthly	Grab
Volatile Organic Compounds	Quarterly	Grab

2) The permittee shall monitor, record and report the quality of water in the approved monitoring wells Well N-9 (upgradient), Well N-11A (upgradient), Well N3 (downgradient), Well N10 (downgradient), Well N1 (downgradient), and Well #4 (downgradient) as shown on a plan titled "Existing Conditions and Monitoring Wells, Town of Nantucket Surfside Sewer Bed" prepared by Ackme Surveying LLC and dated November 13, 2013 according to the following schedule and other provisions:

Parameter	Sample type	Sampling Frequency
pH	Grab	Monthly
Static Water Level Elevation	Measurement	Monthly
Specific Conductance	Grab	Monthly
Total Nitrogen	Grab	Quarterly
Nitrate Nitrogen	Grab	Quarterly
Total Phosphorus	Grab	Annually
Orthophosphate	Grab	Annually
Volatile Organic Compounds	Grab	Annually

a) The Department reserves the right to require more frequent monitoring if the Department determines that phosphorus levels are impacting downgradient receptors.

b) Static Water Level shall be expressed as an elevation and shall be referenced to the surveyed datum established for the site. It shall be calculated by subtracting the depth to the water table from the surveyed elevation of the top of the monitoring well's PVC well casing/riser.

3) The Permittee shall monitor and sample water quality at Stations SMAST 2A and (Head of Harbor – Lower) and SMAST Station 4 (East Polpis Harbor) as identified in the Massachusetts Estuaries Project technical report titled "Linked Watershed Embayment Model to Determine Critical Nitrogen Loading Thresholds for Nantucket Harbor, Nantucket, Massachusetts" and Station M11 as identified in the Massachusetts Estuaries Project technical report titled "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Threshold for the Madaket Harbor and Long Pond Estuarine System, Town of Nantucket, MA" according to the following schedule:

Sampling Frequency	**Parameter**	**Sample Type**	**Reporting Frequency**
Twice a month during July - September	Particulate Organic Nitrogen (PON), Dissolved Organic Nitrogen (DON), Dissolved Inorganic Nitrogen (DIN), Total Nitrogen, DO, Chlorophyll, Secchi Depth, salinity	Grab/Observation	Annually by January 31 of the year following the samples

4) The Permittee shall monitor and sample water quality at Station SES as identified in the Massachusetts Estuaries Project technical report titled "Linked Watershed Embayment Model to Determine Critical Nitrogen Loading Thresholds for Sesachacha Pond, Nantucket, Massachusetts" according to the following schedule:

Sampling Frequency	**Parameter**	**Sample Type**	**Reporting Frequency**
Seven (7) days prior to a pond opening and seven (7) days after pond closure.	Particulate Organic Nitrogen (PON), Dissolved Organic Nitrogen (DON), Dissolved Inorganic Nitrogen (DIN), Total Nitrogen, DO, Chlorophyll, Secchi Depth, salinity	Grab/Observation	Annually by January 31 of the year following the samples

a) If pond depth is greater than 1.5 meters, surface and bottom water quality samples shall be taken. If pond depth is less than 1.5 meters, then the sample shall be taken at mid-depth.

5) Any grab sample or composite sample required to be taken less frequently than daily shall be taken during the period of Monday through Friday inclusive. All composite samples shall be taken over the operating day.

6) The permittee shall submit all monitoring reports within 30 days of the last day of the reporting month. Reports shall be on an acceptable form, properly filled and signed and shall be sent to: the Chief of Wastewater Management – Cape and Islands, Bureau of Water Resources, Department of Environmental Protection, Southeast Regional Office, 20 Riverside Drive, Lakeville, MA02347 and to the Department of Environmental Protection, Bureau of Water Resources, Wastewater Management Program, One Winter Street/5th Floor, Boston, MA 02108, and to the Board of Health, 2 Fairgrounds Rd., Nantucket, MA 02554

a) Submission of monitoring reports in electronic format is available through eDEP and serves as data submission to both the Regional and Boston offices. To register for electronic submission go to: *http://www.mass.gov/eea/agencies/massdep/service/online/edep-online-filing.html*

C. Supplemental Conditions

1) The permittee shall notify the Department at least thirty (30) days in advance of the proposed transfer of ownership of the facility for which this permit is written. Said notification shall include a written agreement between the existing and new permittees containing a specific date for transfer of permit, responsibility, coverage and liability between them.

2) A staffing plan for the facility shall be submitted to the Department once every two years and whenever there are staffing changes. The staffing plan shall include the following components:

a) The operator(s)'s name(s), operator grade(s) and operator license number(s);
b) The number of operational days per week;
c) The number of operational shifts per week;
d) The number of shifts per day;
e) The required personnel per shift;
f) Saturday, Sunday and holiday staff coverage;
g) Emergency operating personnel

3) The permittee is responsible for the operation and maintenance of all sewers, pump stations, and treatment units for the permitted facility, which shall be operated and maintained under the direction of a properly certified wastewater operator.

4) Operation and maintenance of the proposed facility must be in accordance with 314 CMR 12.00, "Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works and Indirect Discharges", and, 257 CMR 2.00, "Rules and Regulations for Certification of Operators of Wastewater Treatment Facilities".

   a) The facility has been rated (in accordance with 257 CMR 2.00), to be a Grade 6 facility. Therefore, the permittee shall provide for oversight by a Massachusetts Certified Wastewater Treatment plant operator (Chief Operator) Grade 6 or higher. The permittee will also provide for a backup operator who shall possess at least a valid Grade 6 license.

   b) The date and time of the operator's inspection along with the operator's name and certification shall be recorded in the log book on location at the treatment facility. All daily inspection logs consistent with the O&M Manual requirements shall be kept at the facility for a period of three (3) years.

   c) Records of operation of wastewater treatment facilities or disposal systems required by the Department shall be submitted on forms supplied by the Department or on other forms approved by the Department for such use. Monthly reports shall be certified by the wastewater treatment plant operator in charge and shall be included in the discharge monitoring reports submitted each month.

5) If the operation and maintenance of the facility is contracted to a private concern, the permittee shall submit a copy of the contract, consistent with what is required by the approved Operation & Maintenance manual and signed only by the contractor, to the appropriate MassDEP Regional Office within thirty (30) days of permit issuance. Along with the contract, a detailed listing of all contract operation obligations of the proposed contractor at other facilities shall also be submitted.

7) All tests or analytical determinations to determine compliance with permit standards and requirements shall be done using tests and procedures found in the most recent version of *Standard Methods for the Examination of Water and Wastewater* and shall be performed by a Massachusetts Certified laboratory.

8) The permittee shall notify the appropriate MassDEP Regional Office, in writing, within thirty (30) days of the following events:

   a) The date of treatment plant start up.
   b) Any interruption of the treatment system operation, other than routine maintenance.
   c) Final shutdown of the treatment system.

9) The permittee shall contract to have any and all solids and sludges generated by the treatment system for which this permit is issued removed off site by a properly licensed waste hauler for disposal at an EPA/MassDEP approved facility. The name and license number of the hauler along with the quantity of wastes removed and the date(s) of

removal shall be reported by the permittee in writing to the appropriate MassDEP Regional Office.

10) Simultaneously with the permit renewal application at year fifteen (2030) following the initiation of plant operations, the permittee shall submit an engineering report, prepared by a registered professional engineer, that outlines in sufficient detail what modifications (if any) to the facility or other changes are required to insure that the facility can remain in compliance with its GWDP and other applicable requirements through the next 5 year permit term (year 2025) and beyond to the Department for its review and approval.

11) In the event that effluent limits are not met, or the discharge is determined to impair groundwater quality in accordance with 314 CMR 5.16(1), the permittee may be obligated to modify, supplement or replace the permitted treatment process so as to ensure that the discharge does not impair the ability of the groundwater to act as an actual or potential source of potable water.

12) Pursuant to M.G.L. Chapter 21A, section 18(a), and 310 CMR 4.03, holders of this Permit may be subject to annual compliance assurance fees as assessed each year on July 1st and invoiced by MassDEP. Failure of the Permit holder to pay applicable annual compliance assurance fees shall result in the automatic suspension of the permit by operation of law under the statute. If fee non-payment continues for sixty days or more, MassDEP has the statutory option of revoking the Permit, denying any other pending permit applications filed by the Permit holder or taking other enforcement action. Permit holders are required to notify MassDEP in writing if they wish to relinquish or transfer a permit. Failure to do so will result in the continued assessment of fees.

D. Appeal Rights

During the thirty (30) day period following issuance of this permit, a Notice of Claim for an Adjudicatory Appeal may be sent by any person aggrieved (the "Petitioner") by the issuance to:

Case Administrator
Office of Appeals and Dispute Resolution
Department of Environmental Protection
One Winter Street/2nd Floor
Boston, MA 02108

310 CMR 1.01(6)(b) requires the Notice of Claim to: include sufficient facts to demonstrate aggrieved person status; state the facts which are grounds for the appeal specifically, clearly and concisely; and, state relief sought. The permit shall become or remain effective at the end of the 30 day appeal period unless the person filing the Notice of Claim requests, and is granted, a stay of its terms and conditions. If a permit is modified under 314 CMR 2.10, only the modified terms and conditions may be subject to an Adjudicatory Appeal. All other aspects of the existing permit shall remain in effect during any such Adjudicatory Appeal.

Per 310 CMR 4.06, the hearing request to the Commonwealth will be dismissed if the filing fee is not paid. Unless the Petitioner is exempt or granted a waiver, a valid check payable to the Commonwealth to Massachusetts in the amount of $100.00 must be mailed to:

Commonwealth of Massachusetts
Department of Environmental Protection
P.O. Box 4062
Boston, MA 02211

The filing fee is not required if the Petitioner is a city, town, county, or district of the Commonwealth, federally recognized Indian tribe housing authority effective January 14, 1994, or any municipal housing authority; or, per MGL 161A s. 24, the Massachusetts Bay Transportation Authority. The Department may waive the adjudicatory hearing filing fee for a Petitioner who shows that paying the fee will create and undue financial hardship. A Petitioner seeking a waiver must file, along with the hearing request, an affidavit setting forth the facts believed to support the claim of undue financial hardship.

II. GENERAL PERMIT CONDITIONS

The following conditions from 314 CMR 5.16 apply to all individual and general permits:

(1) No discharge authorized in the permit shall cause or contribute to a violation of the Massachusetts Surface Water Quality Standards (314 CMR 4.00) or any amendments thereto. Upon promulgation of any amended standard, this permit may be revised or amended in accordance with such standard and 314 CMR 2.10 and 3.13 or 5.12. Except as otherwise provided in 314 CMR 5.10 (3)(c), 310 CMR 5.10(4)(a)2 and 314 CMR 5.10(9), no discharge authorized in the permit shall impair the ability of the ground water to act as an actual or potential source of potable water. Evidence that a discharge impairs the ability of the ground water to act as an actual or potential source of potable water includes, without limitation, analysis of samples taken in a downgradient well that shows one or more exceedances of the applicable water quality based effluent limitations set forth in 314 CMR 5.10. In those cases where it is shown that a measured parameter exceeds the applicable water quality based effluent limitations set forth in 314 CMR 5.10 at the upgradient monitoring well, evidence that a discharge impairs the ability of the ground water to act as an actual or potential source of potable water is deemed to exist if a measured parameter in any downgradient well exceeds the level of that same measured parameter in the upgradient well for the same sampling period. . A statistical procedure approved by the Department shall be used in determining when a measured parameter exceeds the allowable level.

(2) Duty to comply. The permittee shall comply at all times with the terms and conditions of the permit, 314 CMR 5.00, M.G.L. c. 21, §§ 26 through 53 and all applicable state and federal statutes and regulations.

(3) Standards and prohibitions for toxic pollutants. The permittee shall comply with effluent standards or prohibitions established under § 307(a) of the Federal Act, 33 U.S.C § 1317(a), for toxic pollutants within the time provided in the regulations that establish these standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

(4) Proper operation and maintenance. The permittee shall at all times properly operate and maintain all facilities and equipment installed or used to achieve compliance with the terms and conditions of the permit, and the regulations promulgated at 314 CMR 12.00 entitled "Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works and Indirect Discharges, and 257 CMR 2.00, Rules and Regulations for Certification of Operators of Wastewater Treatment Facilities".

(5) Duty to halt or reduce activity. Upon reduction, loss, or failure of the treatment facility, the permittee shall, to the extent necessary to maintain compliance with its permit, control production or discharges or both until the facility is restored or an alternative method of treatment is provided. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of the permit.

(6) Power Failure. In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

(a) provide an alternative power source sufficient to operate the wastewater control facilities; or

(b) halt, reduce or otherwise control production and/or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

(7) Duty to mitigate. The permittee shall take all reasonable steps to minimize or prevent any adverse impact on human health or the environment resulting from non-compliance with the permit.

(8) Duty to provide information. The permittee shall furnish to the Department within a reasonable time as specified by the Department any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating the permit, or to determine whether the permittee is complying with the terms and conditions of the permit.

(9) Inspection and entry. The permittee shall allow the Department or its authorized representatives to:

(a) Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records required by the permit are kept;

(b) Have access to and copy, at reasonable times, any records that must be kept under the conditions of the permit;

(c) Inspect at reasonable times any facilities, equipment, practices, or operations regulated or required under the permit; and

(d) Sample or monitor at reasonable times for the purpose of determining compliance with the terms and conditions of the permit.

(9A) The permittee shall physically secure the treatment works and monitoring wells and limit access to the treatment works and monitoring wells to those personnel required to operate, inspect and maintain the treatment works and to collect samples.

(9B) The permittee shall identify each monitoring well by permanently affixing to the steel protective casing of the well a tag with the identification number listed in the permit.

(10) Monitoring. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity. Monitoring must be conducted according to test procedures approved under 40 CFR Part 136 unless other test procedures are specified in the permit.

(11) Recordkeeping. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by the permit, and all records of all data used to complete the application for the permit, for a period of at least three years from the date of the sample, measurement, report or application. This period may be extended by request of the Department at any time. Records of monitoring information shall include:

(a) The date, exact place, and time of sampling or measurements;
(b) The individual(s) who performed the sampling or measurement;
(c) The date(s) analyses were performed;
(d) The individual(s) who performed the analyses;
(e) The analytical techniques or methods used; and
(f) The results of such analyses.

(12) Prohibition of bypassing. Except as provided in 314 CMR 5.16(13), bypassing is prohibited, and the Department may take enforcement action against a permittee for bypassing unless:

(a) The bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;
(b) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if the permittee could have installed adequate backup equipment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and
(c) The permittee submitted notice of the bypass to the Department:

1. In the event of an anticipated bypass, at least ten days in advance, if possible; or
2. In the event of an unanticipated bypass, as soon as the permittee has knowledge of the bypass and no later than 24 hours after its first occurrence.

(13) Bypass not exceeding limitations. The permittee may allow a bypass to occur which does not cause effluent limitations to be exceeded, but only if necessary for the performance of essential maintenance or to assure efficient operation of treatment facilities.

(14) Permit actions. The permit may be modified, suspended, or revoked for cause. The filing of a request by the permittee for a permit modification, reissuance, or termination, or a notification of planned changes or anticipated non-compliance does not stay any permit condition.

(15) Duty to reapply. If the permittee wishes to continue an activity regulated by the permit after the expiration date of the permit, the permittee must apply for and obtain a new permit. The permittee shall submit a new application at least 180 days before the expiration date of the existing permit, unless permission for a later date has been granted by the Department in writing.

(16) Property rights. The permit does not convey any property rights of any sort or any exclusive privilege.

(17) Other laws. The issuance of a permit does not authorize any injury to persons or property or invasion of other private rights, nor does it relieve the permittee of its obligation to comply with any other applicable Federal, State, and local laws and regulations.

(18) Oil and hazardous substance liability. Nothing in the permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under § 311 of the Federal Act, 33 U.S.C. § 1321, and M.G.L. c. 21E.

(19) Removed substances. Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed in a manner consistent with applicable Federal and State laws and regulations including, but not limited to, the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26 through 53 and the Federal Act, , 33 U.S.C. § 1251 *et seq*, the Massachusetts Hazardous Waste Management Act, M.G.L. c. 21C, and the Federal Resource Conservation and Recovery Act, 42 U.S.C. § 6901, *et seq.*, 310 CMR 19.000 and 30.000, and other applicable regulations.

(20) Reporting requirements.

(a) Monitoring reports. Monitoring results shall be reported on a Discharge Monitoring Report (DMR) at the intervals specified elsewhere in the permit. If the permittee monitors any pollutant more frequently than required by the permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the DMR.

(b) Compliance schedules. Reports of compliance or non-compliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of the permit shall be submitted no later than 14 days following each schedule date.

(c) Planned changes. The permittee shall give notice to the Department as soon as possible of any planned physical alterations or additions to the permitted facility or activity which could significantly change the nature or increase the quantity of pollutants discharged. Unless and until the permit is modified, any new or increased discharge in excess of permit limits or not specifically authorized by the permit constitutes a violation.

(d) Anticipated non-compliance. The permittee shall give advance notice to the Department of any planned changes in the permitted facility or activity which may result in non-compliance with permit requirements.

(e) 24 hour reporting. The permittee shall report any non-compliance which may endanger health or the environment. Any information shall be provided orally within 24 hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the non-compliance, including exact dates and times, and if the non-compliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the non-compliance. The following shall be included as information which must be reported within 24 hours:

1. Any unanticipated bypass which exceeds any effluent limitation in the permit.

2. Any violation of a maximum daily discharge limitation for any of the pollutants listed by the Department in the permit to be reported within 24 hours.

(f) Other non-compliance. The permittee shall report all instances of non-compliance not reported under 314 CMR 5.16(20)(a), (b), or (e) at the time monitoring reports are submitted. The reports shall contain the information listed in 314 CMR 5.16(20)(e).

(g) Toxics. All manufacturing, commercial, mining, or silvicultural dischargers must notify the Department as soon as they know or have reason to believe:

1. That any activity has occurred or will occur which would result in the discharge of any toxic pollutant listed in 314 CMR 3.17 which is not limited in the permit, if that discharge will exceed the highest of the following notification levels:

a. 100 micrograms per liter (100 ug/l);

b. 200 micrograms per liter (200 ug/l) for acrolein and acrylonitrile; 500 micrograms per liter (500 ug/l) for 2,4-dinitrophenol and for 2-methyl-4,6-dinitrophenol; and one milligram per liter (1 mg/l) for antimony;

c. Five times the maximum concentration value reported for that pollutant in the permit application; or

2. That they have begun or expect to begin to use or manufacture as an intermediate or final product or byproduct any toxic pollutant which was not reported in the permit application.

(h) Indirect dischargers. All Publicly Owned Treatment Works shall provide adequate notice to the Department of the following:

1. Any new introduction of pollutants into the POTW from an indirect discharger which would be subject to § 301 or 306 of the Federal Act, 33 U.S.C. § 1311 or 1316, if it were directly discharging those pollutants; and

2. Any substantial change in the volume or character of pollutants being introduced into the POTW by a source introducing pollutants into the POTW at the time of issuance of the permit.

(i) Information. Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit such facts or information.

(j) The permitte shall notify the Department in writing within seven days of any change in contract operators.

(21) Signatory requirement. All applications, reports, or information submitted to the Department shall be signed and certified in accordance with 314 CMR 3.15 and 5.14.

(22) Severability. The provisions of the permit are severable, and if any provision of the permit, or the application of any provision of the permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of the permit, shall not be affected thereby.

(23) Reopener clause. The Department reserves the right to make appropriate revisions to the permit in order to establish any appropriate effluent limitations, schedules of compliance, or other provisions which may be authorized under the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26 through 53 or the Federal Act, 33 U.S.C. §1251 *et seq* in order to bring all discharges into compliance with said statutes.

(24) Approval of treatment works. All discharges and associated treatment works authorized herein shall be consistent with the terms and conditions of this permit. Any modification to the approved treatment works shall require written approval of the Department prior to the construction of the modification.

(25) Transfer of Permits.

(a) RCRA facilities. Any permit which authorizes the operation of a RCRA facility which is subject to the requirements of 314 CMR 8.07 shall be valid only for the person to whom it is issued and may not be transferred.

(b) Transfers by modification. Except as provided in 314 CMR 5.16(25)(a) and (c), a

permit may be transferred by the permittee to a new owner or operator provided that the permit has been modified or revoked and reissued or a minor modification is made to identify the new permittee in accordance with 314 CMR 5.12(3) and (4).
(c) Automatic transfers. For facilities other than Privately Owned Wastewater Treatment Facilities (PWTFs) that treat at least some sewage from residential uses, hospitals, nursing or personal care facilities, residential care facilities, and/or assisted living facilities, PWTFs that have been required to establish financial assurance mechanism(s) pursuant to 314 CMR 5.15(6), and RCRA facilities subject to the requirements of 314 CMR 8.07, a permit may be automatically transferred in accordance with 314 CMR 5.12(5).

(26) Permit Compliance Fees and Inspection Information. Except as otherwise provided, any permittee required to obtain a surface water or ground water discharge permit pursuant to M.G.L. c. 21, § 43 and 314 CMR 3.00 and 5.00, shall be required to submit the annual compliance assurance fee established in accordance with M.G.L. c. 21A, § 18 and 310 CMR 4.00 as provided in 314 CMR 2.12. The requirement to submit the annual compliance fee does not apply to any local government unit other than an authority. Any permittee required to obtain a surface water or ground water discharge permit pursuant to M.G.L. c. 21, §43 and 314 CMR 3.00 and 5.00 may be required to submit inspection information annually as a condition of the permit as provided in 314 CMR 2.12.

Individual Groundwater Discharge Permit
Fact Sheet

I. APPLICANT, FACILITY INFORMATION, and DISCHARGE LOCATION

Name and Address of Applicant:
Town of Nantucket (Sewer Department)

Name and Address of Facility where discharge occurs:

Surfside Wastewater Treatment Facility
South Shore Dr.
Nantucket, MA 02554

Discharge Information:

Groundwater Discharge Permit Number:

The Groundwater Discharge Permit will allow the applicant to discharge 4.0 million gallons per day (MGD) of treated sanitary wastewaster from an existing municipal sewage treatment facility to groundwaters of the Commonwealth. The discharge is not located in a sensitive area.

II. LIMITATIONS AND CONDITIONS

Discharge permit limitations are as listed in the ground water permit and are in conformance with 314 CMR 5.00, the Groundwater Discharge Permit Program.

III. PERMIT BASIS AND EXPLANATION OF EFFLUENT LIMITATIONS

An Individual Groundwater Discharge permit is required for this discharge in accordance with the Massachusetts Clean Water Act, M.G.L. c. 21, s. 26-53 and 314 CMR 5.03.

Effluent limitations are based upon the location of the discharge, the level of treatment, consideration of human health protection criteria and protection of the groundwaters of the Commonwealth.

This permit is a renewal of the existing groundwater discharge permit with an allowance to increase the maximum daily discharge from 3.4 MGD to 4.0 MGD. The Applicant has demonstrated to MassDEP's satisfaction that the existing open sand infiltration beds can accommodate the increase in flow.

IV. COMMENT PERIOD, HEARING REQUESTS, AND PROCEDURES FOR FINAL DECISIONS

The public comment period for this permit is thirty (30) days following public notice in *The Environmental Monitor*. The public notice for this Individual Groundwater Discharge Permit occurred on December 9, 2015.

Requests for an adjudicatory hearing must be submitted within thirty (30) days of the issuance/denial of the permit, by any person who is aggrieved by such issuance/denial.

A final decision on the issuance/denial of this permit will be made after the public notice period, and review of any comments received during this period.

V. STATE CONTACT INFORMATION

Additional information concerning the draft permit may be obtained between the hours of 9:00 a.m. and 5:00 p.m. Monday through Friday excluding holidays, from:

Brian Dudley
MassDEP
20 Riverside Drive
Lakeville, MA 02347
(508)946-2814
Brian.dudley@state.ma.us

Brian A. Dudley, Section Chief
Wastewater Management – Cape and Islands

NOVEMBER 19, 2019
DATE

APPENDIX B

WPI Food Asset Map Study

Nantucket Food Asset Map

An Interactive Qualifying Project submitted to the Faculty of WORCESTER POLYTECHNIC INSTITUTE in partial fulfilment of the requirements for the degree of Bachelor of Science.

Katelyn Burke, Mikala Dunbar, Jonathan Jironvil, Rachel Lia

Advisors: Professors Dominic Golding & Richard Vaz

Sustainable Nantucket, Nantucket Food Pantry, Food Rescue Nantucket

December 13, 2017

Abstract

Nantucket's sustainability movement is partially sparked by the large amount of food imported to feed its fluctuating population, caused by summer tourism. The goal of this project was to develop an interactive food asset map and database for Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket to identify areas to expand food production, improve food distribution to recipients, and reduce food waste on Nantucket. Our approach included interviews with stakeholders and the assessment of databases, in addition to site visits and observations. After developing the map and database, we analyzed the food system; suggesting areas for production expansion, program improvements and future developments for food-focused organizations on island.

Acknowledgements

We would like to thank everyone that helped us accomplish our project! In particular:

Our sponsor organizations for working with us to meet everyone needs and start to connect the community.

Sustainable Nantucket: Michelle Whelan, Yeshe Palmo, Calin Duke

Nantucket Food Pantry: Anne Marie Bellavance

Food Rescue Nantucket: Gary Langley

Interviewees who gave us helpful information about many aspects of our project.

Town GIS Coordinator: Nathan Porter

Land Bank Assistant Director: Jesse Bell

Health Department Director: Roberto Santamaria

Natural Resources Department Coordinator: Jeff Carlson

Nantucket Yacht Club General Manager: Peter McEachern

Local restaurants owners who participated in the survey and interviews

The Nantucket High School for wanting to take on updating and maintaining the map.

Dan Farrell, Jed Williams, & all the students!

Local businesses for welcoming us to the island.

Young's Bicycle Shop: Harvey Young for generously lending us bikes

Maria Mitchell Association for opening up housing for us

Nantucket Shipwreck & Lifesaving Museum

ReMain Nantucket

WPI advisors who helped us push us along through the project to produce great work.

Dominic Golding & Richard Vaz

Executive Summary

Sustainable agriculture works to meet the food needs of today without compromising the food security of tomorrow. The sustainable movement, sparked largely by the growing fear of global environmental crises and natural disasters, is pushing for self-sustaining practices, locally-produced food, and community food network analysis. However, in the United States there is still an estimated 133 billion pounds of food that ends up in landfills annually (United States Department of Agriculture, n.d.).

Nantucket is an island community that used to be agriculturally focused, but now imports most of its food. Imported food requires added transportation which, according to an Environmental Research Letters journal article, has multiple impacts "such as resource depletion, pollution, climate disturbance, and biodiversity reduction" (Dalin & Rodriguez-Iturbe, 2016). Promoting and increasing locally-produced food helps provide fresh produce to supplement the food supply being imported. Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket are three organizations promoting sustainable food activities on the island. Improving the food system requires understanding and analyzing Nantucket's current resources.

➢ Approach

On Nantucket, we were given the opportunity to work on a Comprehensive Food System Assessment, a long-term plan set forth by the three organizations. The goal of our project was to develop a map that identifies places on Nantucket where people can grow, prepare, share, buy, receive, or learn about food. We conducted interviews with stakeholders on and off-island, administered surveys to restaurants, and reviewed existing database materials in Geographic Information Systems (GIS) and other on-island sources. We gathered data to compile the food asset map and database such as address, contact information, and availability.

➢ Food Asset Map and Database

The purpose of this map is to visualize the aspects current food cycle and spark changes to improve the system.

➢ Production

Our map of producers on Nantucket includes: apiaries, florists, farmers, oyster farmers, fisherman, and other select producers. Below in Figure a are producers on Nantucket in black diamonds.

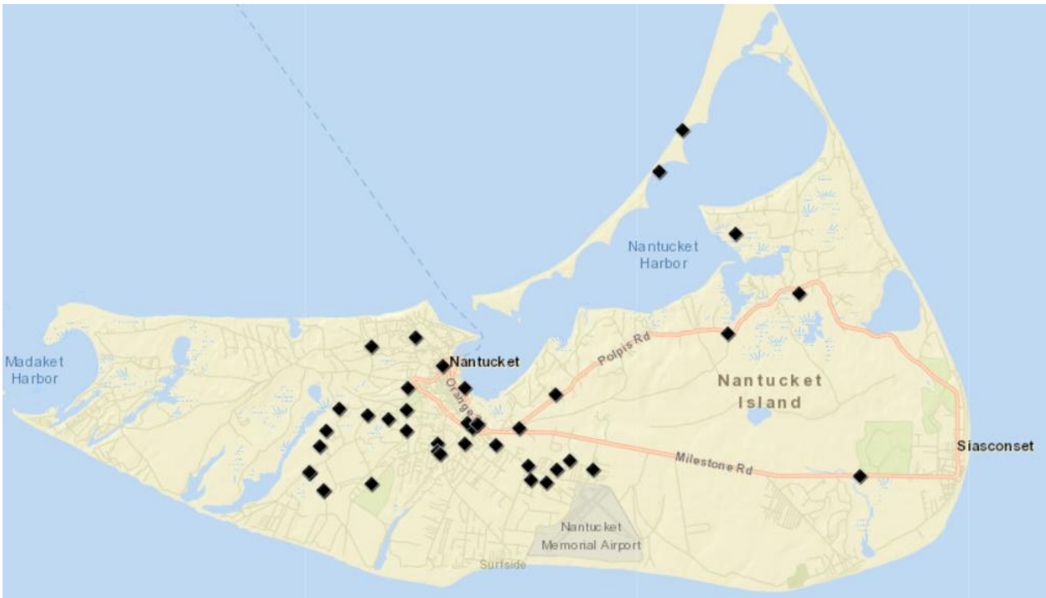

Figure a: Producers on Nantucket

We identified farms in order to understand the island's food production. We noted areas of aquaculture, which occur around the island by private growers and by the town, occupying about 100 acres of land altogether. Currently, there are open plots of aquaculture reserved by the Natural Resources Department available for use in Polpis Harbor.

- Distribution

Figure b shows distributors involved in the Nantucket food system (orange squares) and also food storage facilities on the island (green circle). Off-island distributors import the vast majority of the food on island which can become a problem when ferries cancel due to high winds. On-island locations with freezers and refrigerators are particularly valuable because organizations are able to store perishable foods.

Figure b: Distributors on and off island.

➢ Consumption

Many Nantucket restaurants and inns are seasonal, however, there currently is not a program in Nantucket to use commercial kitchens in off-times (either at night or during the end of a season). If the Nantucket Food Pantry had access to these unused spaces, it could pre-package its own food, increasing the kinds of donations it can receive.

➢ Recommendations

Production expansion: There are open areas for aquaculture and agriculture on the island that can be utilized in the food system cycle.

- ❖ We encourage the use of the open plots of aquaculture reserved by the Natural Resources Department in Polpis Harbor by current growers or by implementing a program to train new growers.
- ❖ We recommend more exploration of agricultural expansion on the island. Criteria that make land suitable is: it has been used for an agricultural purpose in the past 15 years.

Future developments: A stronger, more developed food network on Nantucket can lead to a more effective system in the community.

- We encourage the Nantucket Food Pantry to work with the Nantucket Health Department and interested commercial kitchens to arrange licensing to use vacant commercial kitchens.
- We recommend that Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket work together in establishing a local Food Hub through Sustainable Nantucket's CFI.

Food-focused programs: We recommend the implementation and expansion of several programs to help further the goals of Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket.

- We encourage the Nantucket Food Pantry and Sustainable Nantucket to better promote their *Share Your Harvest* program and partner with Food Rescue Nantucket to organize gleaning and pick-ups.
- We recommend Food Rescue Nantucket expand gleaning beyond the current two farms: Moors End Farm and Bartlett's Farm.
- The number and locations of Food Rescue Nantucket box locations could be expanded to make it convenient for more residents.
- We recommend that the Nantucket Food Pantry work with the Nantucket Atheneum to implement a *Food for Fines* program, allowing library members to exchange non-perishable food items for a reduction of library fines.

Communication: We recommend enhancing communication between the organizations and others involved in the food network through the use of various applications (i.e. the program *Slack*).

Updating the Map: We suggest that Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket continue to work with the Nantucket High School students to update the map annually. We created a user manual to explain this process and aid in keeping the map current.

Map Promotion: We recommend that Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket promote the food asset map through the use of different forms of media to reach the largest audience.

Authorship

Katelyn Burke (KB); Mikala Dunbar (MD); Jonathan Jironvil (JJ); Rachel Lia (RL)

Section	Primary Author	Primary Editor	Secondary Author	Secondary Editor
Introduction	ALL	KB	ALL	MD
Background				
Sustainable Agriculture	RL	MD	KB	JJ
Food Assets & Networks	RL	MD	KB	JJ
Food Asset Mapping	MD	KB	RL	JJ
Food Insecurity Case Studies	RL	RL	JJ	KB
Nant. Food System Cycle	KB	RL	ALL	ALL
Conclusion	KB	ALL	ALL	ALL
Methodology				
Objective 1	KB	MD	ALL	ALL
Objective 2	MD	MD	KB	RL
Objective 3	JJ	JJ	MD	KB
Objective 4	RL	MD	KB	JJ
Objective 5	RL	MD	KB	JJ
Food System on Nantucket				
Food System Cycle	ALL	KB	ALL	ALL
Map/Database Content, Usage	JJ	KB	MD	RL
Conclusions/Recommendations				
Production Expansion	KB	RL	MD	JJ
Future Developments	MD	RL	KB	JJ
Food-Focused Programs	MD	KB	RL	JJ
Nant. High School Program	MD	KB	RL	JJ
Communication	RL	KB	KB	MD
Map Promotion	RL	MD	KB	JJ
Appendices				
Appendix A	KB	RL	MD	JJ
Appendix B	MD	KB	RL	JJ
Appendix C	KB	MD	RL	JJ
Appendix D	KB	MD	RL	JJ
Appendix E	MD	RL	KB	JJ
Appendix F	KB	RL	JJ	MD
Appendix G	MD	KB	JJ	RL
Appendix H & I	ALL	ALL		
ArcGIS Map Creation	JJ	ALL		

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Introduction

Sustainable agriculture works to meet the food demands of today without compromising the food security of tomorrow. The sustainable movement, sparked largely by the growing fear of global environmental crises and natural disasters, is pushing for self-sustaining practices, locally-produced food, and community food network analysis. Communities are increasingly promoting locally-sourced food through farmers markets, providing fresh produce to food pantries and local schools, as well as practices such as gleaning that reduce food waste. However, there still remains an estimated 133 billion pounds of food that is produced annually, never eaten, and ends up in landfills (United States Department of Agriculture, n.d.).

Nantucket is an island community that used to be agriculturally focused, but now imports most of its food. Imported food requires added transportation which, according to an Environmental Research Letters journal article, has multiple impacts "such as resource depletion, pollution, climate disturbance, and biodiversity reduction" (Dalin & Rodriguez-Iturbe, 2016). In addition, imported food raises food prices due to the added effort in transporting and storing the food, and is not as fresh as locally-produced food. Promoting and increasing locally-produced food helps provide fresh produce to supplement the food supply being imported. However, as a developed island community with relatively little room for expansion, Nantucket's opportunity to grow agricultural resources is limited.

Sustainable Nantucket, Nantucket Food Pantry and Food Rescue Nantucket are three organizations on the island promoting sustainable food activities. Sustainable Nantucket promotes sustainable agriculture to protect the environment while increasing the island's self-reliance. The Nantucket Food Pantry provides vital support to many food-insecure families and, and Food Rescue Nantucket works to stop food from being wasted.

Community mapping is a practical visualization technique to help identify and promote sustainable food practices. Food asset maps can be used to identify where food is produced, received, distributed, or wasted in the community. This can highlight spaces not being used to their full potential or areas that show possibilities for future production expansion; and thus be beneficial for local food-focused organizations.

The goal of this project was to develop a map that identifies places on Nantucket where people can grow, prepare, share, buy, receive, or learn about food. We identified five objectives to achieve this goal. Accordingly, we:

1. Identified and evaluated best practices in the development of food asset maps and databases
2. Clarified details of the purpose, content, and format of the food asset map and database with respect to the goals set forward by Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket
3. Built a food asset map and database
4. Used the food asset map to analyze Nantucket's food system (production, distribution, consumption, waste) in order to identify opportunities for improvement
5. Integrated the food asset map with existing programs and developed a strategy to update and maintain the map and database

In order to achieve these objectives, we conducted interviews with stakeholders on and off-island, administered surveys to restaurants, and reviewed existing database materials in GIS and other on-island sources. We gathered information on GIS software practices, food asset maps, production expansion, and gleaning opportunities; synthesizing it into a food asset map. This is the initial step of the long-term plan set forth by Sustainable Nantucket, Nantucket Food Pantry and Food Rescue Nantucket of a Comprehensive Food System Assessment. We hope that the three organizations will be able to use the food asset map as a tool to analyze and enhance the Nantucket food system.

Background

In this chapter, we first discuss the history of farming over the past 100 years in the United States and how changes in technology affected the sustainability of the practices used. We then explain food assets and the workings of food system cycles. We give examples of other food asset maps that improved communities' food system cycles. Then we dive deeper into case studies in New England and how they combat food insecurity. Finally, we end with a discussion of Nantucket's efforts to promote sustainability.

I. Sustainable Agriculture

Over the past 100 years there has been a dramatic change in farming practices in the United States. After technological advances in the 1940s, farmers were able to more efficiently work their land, subsequently allowing them to increase production while decreasing labor required. As a result, the average size of farms increased and the number of farms declined (as seen in Figure 1).

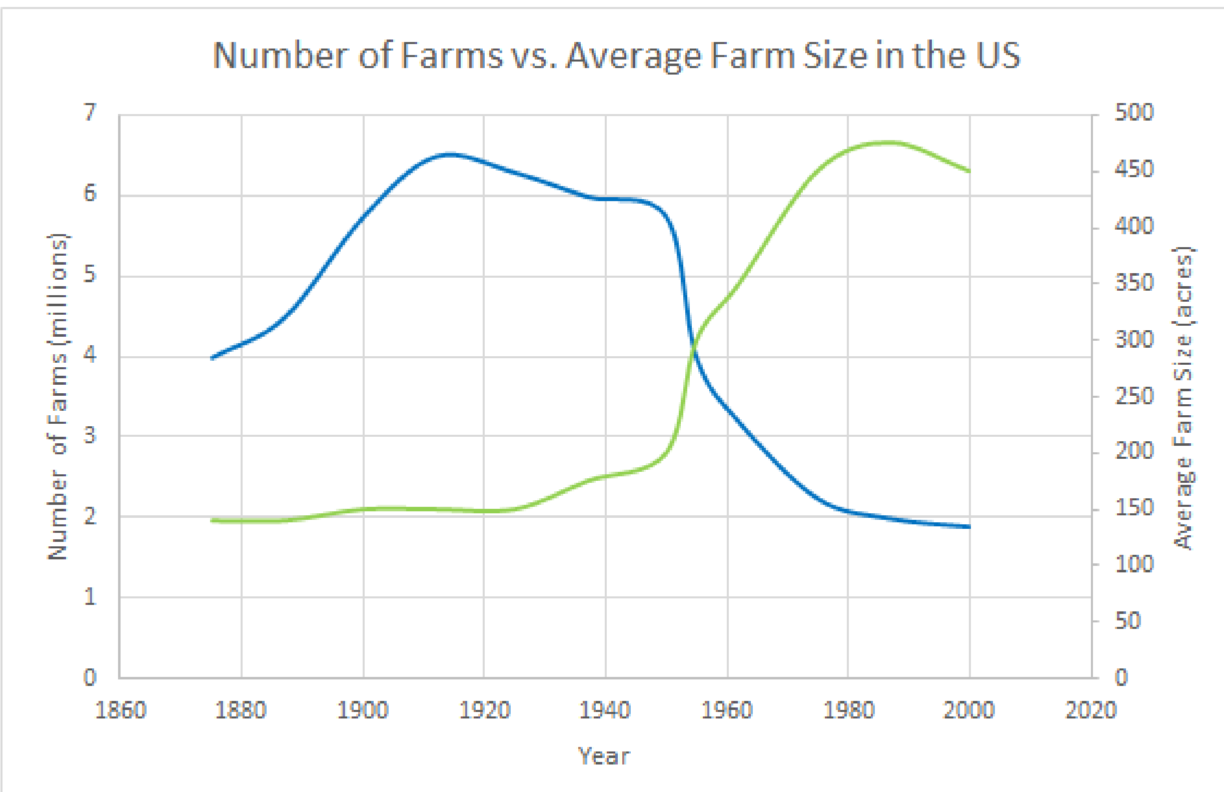

Figure 1: Number of Farms vs. Average Size of Farms in the US (What is sustainable agriculture?, n.d.)

There are many advantages to increased productivity in agriculture; however, there are also many negative impacts. Along with a decrease in the number of small family farms, there was also a decline in the sustainability of the practices used by the larger farms that replaced them. It is often more profitable for these farms to produce only a few key crops. A lack of crop rotation and diversity leads to the depletion of the soil's natural resources, rendering the land less valuable for future farming efforts. The rise in production cost and overall decline in the number of farms also puts an economic strain on communities that were once mostly agrarian. Additional problems that arise from unsustainable agricultural practices include contamination of groundwater and an increased reliance on nonrenewable environmentally damaging energy in order to operate farms. In the past few decades there has been a movement in the United States of America and across the world to promote more sustainable agricultural practices (What is sustainable agriculture?, n.d.).

Sustainability is a relatively new concern in society. Sustainability became a topic of discussion in the late 1970's and early 1980's, but it did not gain traction and become widely accepted until the 1990's. Caradonna (2016) describes sustainability as a way to combat a "moribund economic system that has drained the world of many of its finite resources" (p.4). In the past 100 years, there has been a push in many societies to expand economic capabilities; however, this is often largely at the expense of the ecosystem (p.3).

Sustainable agriculture works to meet the food needs of today without compromising the food security of future generations. To advance this goal sustainable agriculture focuses on promoting economic prosperity, environmental health, and social and economic fairness (What is sustainable agriculture?, n.d.). The rise of sustainable agriculture is shown through the rise in the amount of organic farming and food.

Organic food sales were an estimated $28.4 billion in 2012, about 4% of total food sales in the US (Organic Market Overview, 2017). The largest organic food sale category is produce, as shown in Figure 2. However, organic price premiums show no sign of decreasing due to the increased demand for organic products. These prices limit the accessibility of organic food to the general public and can make it a luxury product (Organic Market Overview, 2017).

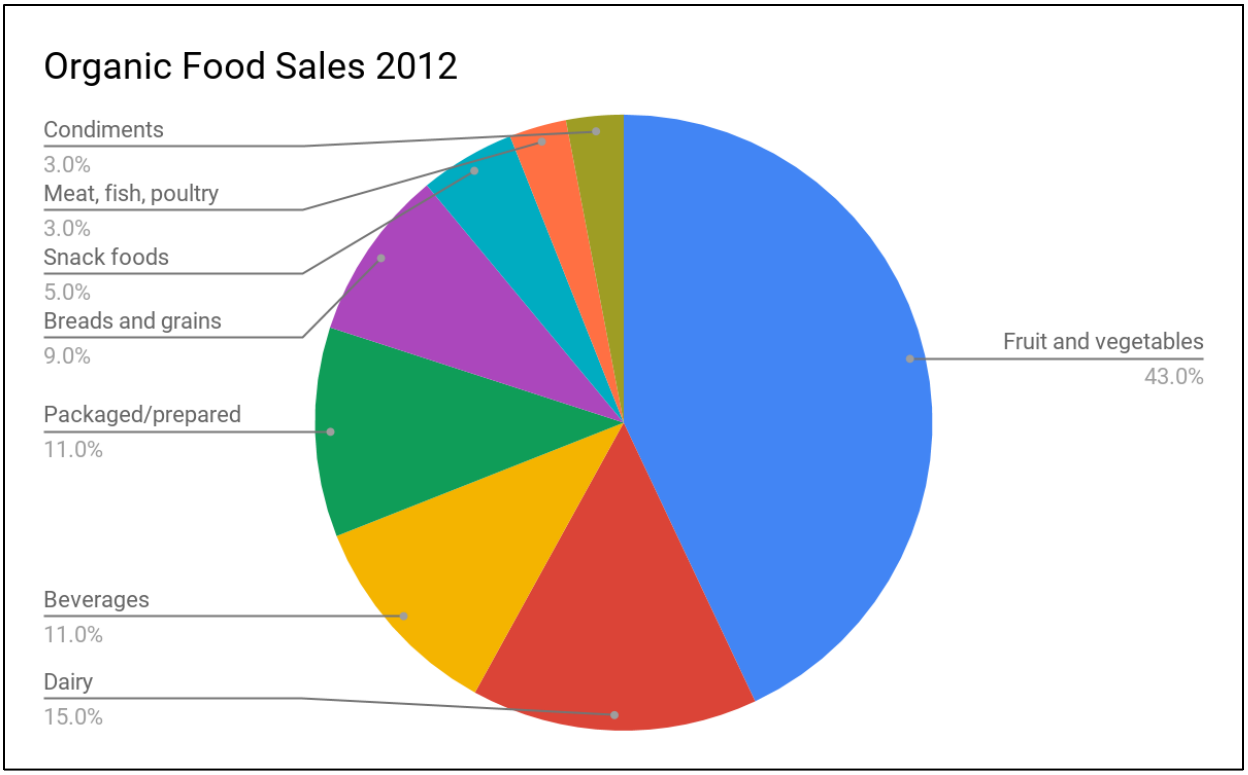

Figure 2: Organic Food Sales 2012 (Organic Market Overview, 2017).

Another indicator of the rise in sustainable agricultural interest is the increase in the number of community supported agriculture (CSA) locations. In 2015, according to the Local Food Marketing Survey by the US Census of Agriculture, CSAs sold $226 million of food directly to consumers, 7% of direct to consumer food sales in the US. These sales are from just 7,398 CSAs nationwide (USDA/NASS QuickStats, 2015).

The rise in sustainability movements is aiding in decreasing overall food waste. However, there is still a large amount of food wasted in the United States, where an estimated 30-40% of the food produced becomes food waste (United States Department of Agriculture, n.d.). The United States Department of Agriculture estimates that in one year alone, $47 billion in food from grocery stores never made it to the homes of consumers and was wasted (n.d.). This statistic only takes into account one step in the food system cycle, not even considering the food that never makes it to stores or gets thrown into landfills. Annually, an estimated 133 billion pounds of food produced is never eaten and ends up in landfills (United States Department of Agriculture, n.d.). An analysis of a community's food assets and food network can identify areas where a community is losing food.

II. Food Assets and Networks

Food assets are locations where a community grows, prepares, shares, buys, receives, or learns about food. Each community has its own food network with each point of the network being a food asset or containing assets within it. *Food networks* (Figure 3) start where food is grown, through to distribution and sale in stores and restaurants, and ends with food waste in compost or landfills (What is sustainable agriculture?, n.d.). An ideal food network eliminates inefficiencies to produce the greatest yield for the least amount of energy.

Figure 3: Local Food System Map (Local food system, 2014).

While there is no universally agreed upon definition for a food system cycle, it is generally defined as the steps the food takes from "soil to soil." This means that it encompasses an entire food system cycle from the time the food is first grown until what remains is discarded. It is important to look at where food loss occurs, and it occurs in every stage of the food cycle.

During the first stage of production there is food left behind during harvest because of poor equipment damaging the food or because the food quality falls below acceptable standards for the harvest. The second stage is the handling and storage of the food. Throughout this stage, there is potential for food to go bad due to pests, diseases, and fungi. Packaging food occurs in the third stage, where food is often spilled, damaged, or deemed "unsuitable for processing." In the distribution phase, food is often discarded because it is not aesthetically pleasing, or is not sold by the "best by date." During the consumption phase, a lot of food is purchased but never eaten, whether it goes bad or is simply thrown out (Lipinski et al., 2013, p. 4). In recent years, many people have begun to question the sustainability of local food cycles; largely prompted by environmental and ethical concerns.

Food sustainability is described by Garnett as, "a collaborative network that integrates sustainable food production, processing, distribution, consumption and waste management in order to enhance the environmental, economic and social health" (2013, p.1). Some experts say there are relatively easy, quick, and cost-effective ways to reduce food waste that can be implemented fairly quickly to help promote more sustainable communities. Some of these solutions include (Lipinski et al., 2013, p.2):

> "1. Develop a food loss and waste measurement protocol
> 2. Set food loss and waste reduction targets
> 3. Increase investment in reducing postharvest losses in developing countries
> 4. Create entities devoted to reducing food waste in developed countries
> 5. Accelerate and support collaborative initiatives to reduce food loss and waste."

Food security is described by Rosegrant and Cline as "need[ing] policy and investment reforms on multiple fronts, including human resources, agricultural research, rural infrastructure, water resources, and farm- and community-based agricultural and natural resources management" (2003, p.1). Food security is the result of many different elements working together soundly to create a more efficient food system cycle.

Resources that help to combat food waste and increase food security in a community include food banks and food pantries. Driven by concern for community equity, they collect and distribute food to reduce food insecurity. Food that otherwise might be wasted can be donated to these organizations; for example, the food at the end of a restaurant's season prior to closure or from large retail grocery stores. Food banks and pantries collect food from a mix of purchasing food and donations. Food banks store up to millions of pounds of food to distribute to multiple communities, while food pantries interact with their clients directly and typically serve one host community. Mobile food pantries are able to connect to more remote areas. Food pantries are typically non-profit organizations assisted by the government and other charitable organizations. Human service charities, such as Feeding America, help distribute supplies to food pantries and food banks (Feeding America, 2017a).

According to Feeding America (2017b), "41 million people struggle with hunger in the United States, including 13 million children. In 2015, 5.4 million seniors struggled to afford enough to eat." However, only 59% of these households participated in at least one of the major federal food assistance programs: the Supplemental Nutrition Assistance Program (SNAP, formerly Food Stamps); the National School Lunch Program; and the Special Supplemental Nutrition Program for Women, Infants and Children (WIC). This illustrates the problem that a large portion of food insecure families fail to access programs that could be beneficial to them. Food pantries work with users and nonusers of these federally funded programs, and are often the only help some food-insecure families receive.

III. Food Asset Mapping

Communities use food asset maps as a way to evaluate and improve their food network. With recent technological advances, mapping has become more accessible for organizations to utilize. Mapping food systems can be beneficial in reducing food waste, promoting an increase in food production, as well as identifying improvements in food distribution.

Two common mapping platforms are: Geographic Information Systems (GIS) and Google Maps. As Lefer (2008) details, "[t]he development and availability of geographic information systems (GIS) has greatly expanded the sophistication and analytic power of mapping," adding that it assists to "serve to involve, inform, and educate students and community members" (p.475). GIS maps have an extensive collection of data indicators and can support a diverse information database behind their display. These data layers can be combined or viewed separately. GIS maps can be created, moved online, and viewed publicly through ArcGIS Online and the software ArcMap. Through these mediums, GIS maps can be customized by icon and information displayed.

In 2010, a project developed by the Johns Hopkins Center for a Livable Future involved creating a GIS food asset map for the state of Maryland. The map started with 30 data indicators in the GIS software, which in just the past five years have grown to over 175 (Fisher, Burns, & Harding, 2017). This is a large-scale food asset map and allows for the visualization of larger trends and analysis of patterns. For example, Figure 4 shows the commercial value of oyster landings by area in 2012. The dark blue represents the higher commercial value of oyster operations, and the green and white areas are of lesser commercial value.

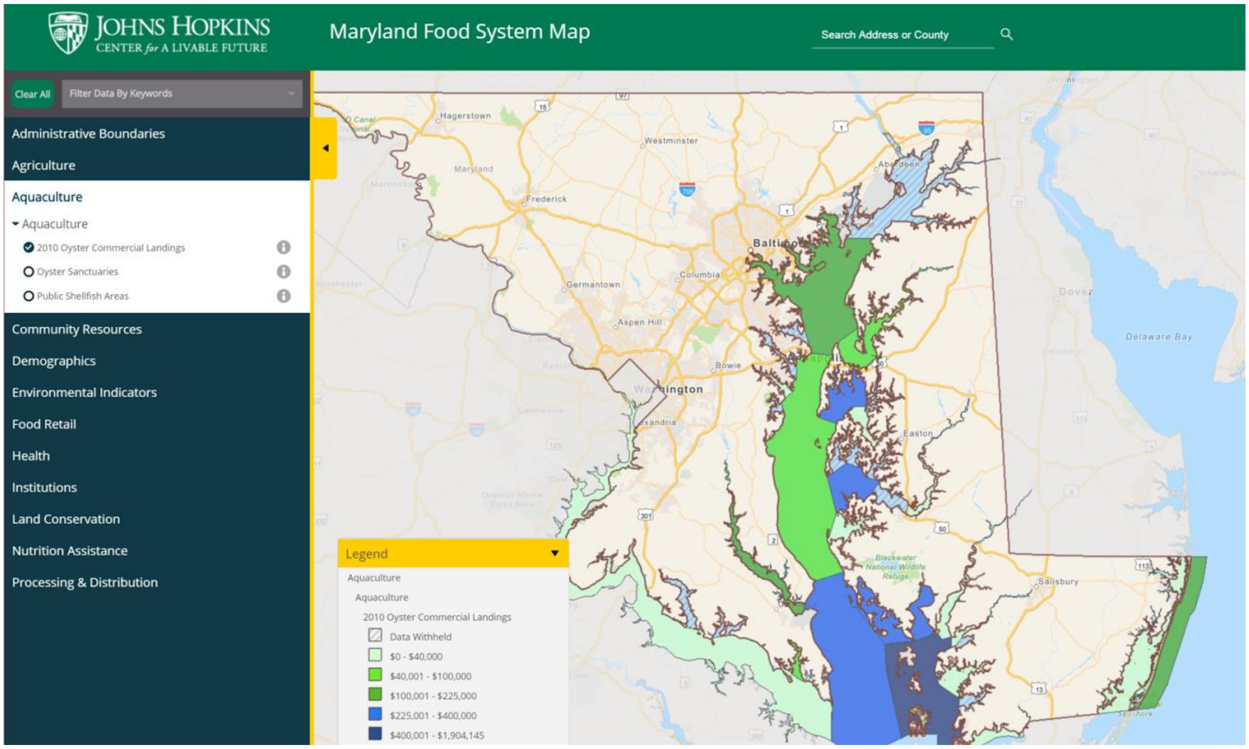

Figure 4: Maryland Food System Map showing 2010 Oyster Commercial Landings (Fisher, Burns & Harding, 2017a).

In contrast with the block mapping of areas of interest in Figure 4, point mapping can be effective in showing the distribution of discrete locations. For example, the Maryland Food Systems Map (Figure 5) shows point locations of farms selling locally in 2015.

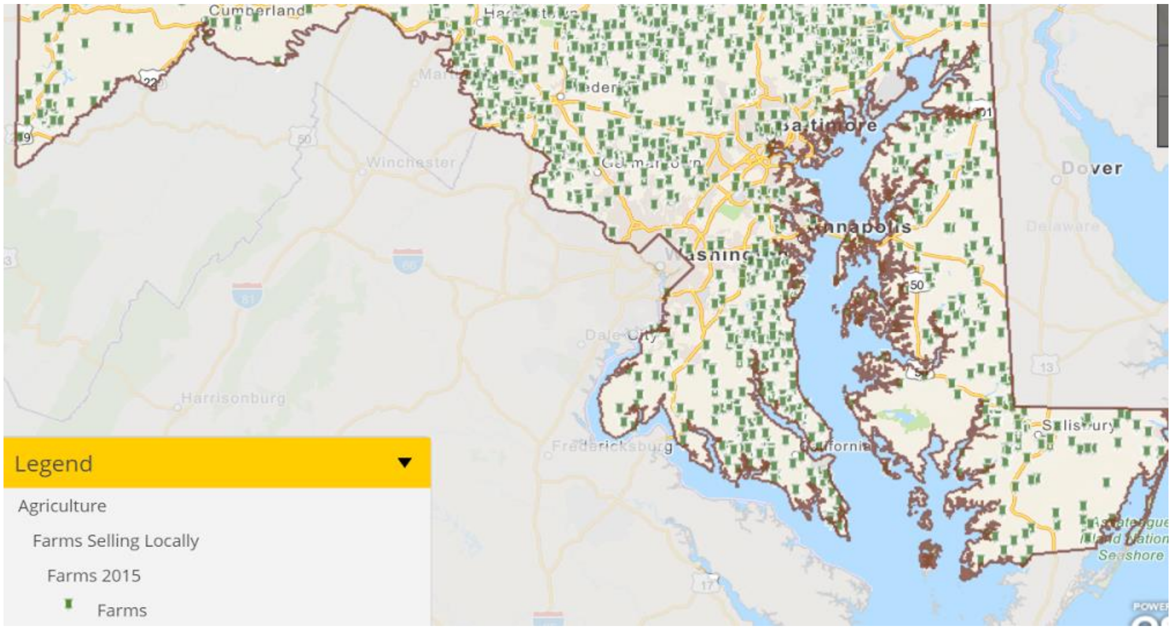

Figure 5: Maryland Food System Map showing Farms Selling Locally in 2015 (Fisher, Burns & Harding, 2017b).

The Maryland Food System Map database includes a variety of other mapped data, such as: census data of cattle, dairy, grain, hog, farms, government payments, net cash farm income, plant hardiness by temperature, and pantry and free meal sites.

Another application of food asset mapping is to identify food deserts. The Johns Hopkins Center for a Livable Future defines a food desert as "an area where the distance to a supermarket or supermarket alternative is more than 1/4 mile, the median household income is at or below 185% of the Federal Poverty Level, over 30% of households have no vehicle available, and the average Healthy Food Availability Index (HFAI) score for all food stores is low" (Buczynski, Buzogany, and Freishtat, 2015). In 2015, the Johns Hopkins Center for a Livable Future evaluated food deserts in Baltimore City, MD. Using mapped data, the study concluded that (Buczynski, Buzogany, & Freishtat, 2015):

1. "[o]ne in four of Baltimore City residents live in areas identified as food deserts;
2. children are affected disproportionately, with 30 percent living in food deserts;
3. African Americans have disproportionately low access to healthy food and are the most likely of any racial or ethnic group to live in a food desert neighborhood."

Since food deserts are mostly problems in large populated cities affecting more people, they are viewed as a more pressing issue and more research has been done on them as opposed to a food sustainability and asset mapping in small urban, suburban, or rural areas.

The organization FarmFresh, based in Rhode Island, uses a food asset map on its webpage to identify different farms and other agricultural locations in Southern New England. This organization uses Google Maps as a base for its design. The map is easily accessed from the FarmFresh homepage and allows zooming features. Below the map is more information about the agricultural locations in the specific area code with links to learn more about them. The point locations of the farms are shown with an icon of the abbreviation for what kind of food resource it falls under. Figure 6 shows the Federal Hill area in Providence with six agricultural locations. It highlights five CSA areas and a farmer's market (mkt) in gold stars. However, when clicking on these locations, not much information is available and requires leaving the map to access more information.

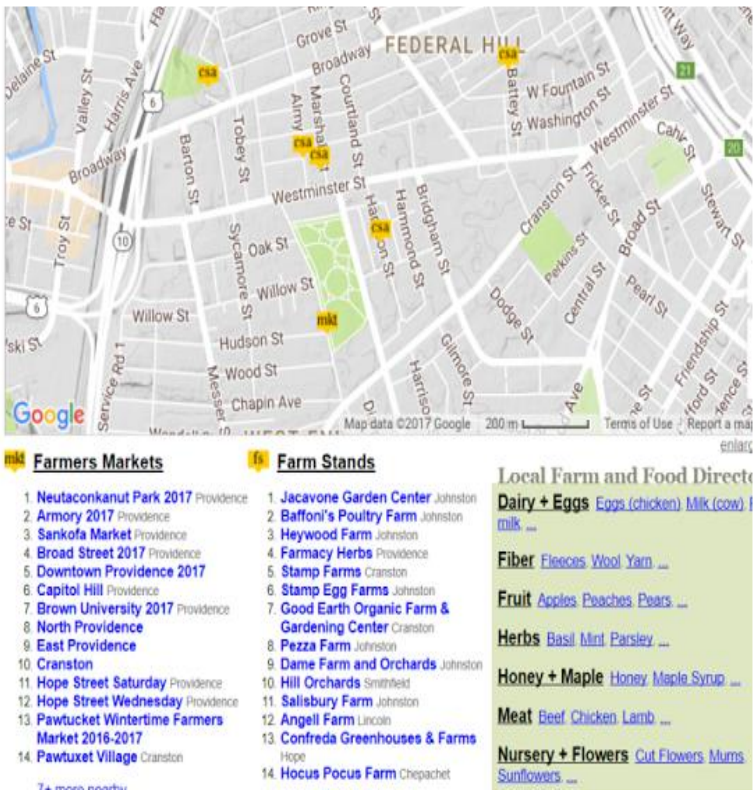

Figure 6: Farm Fresh Food Asset Map (Providence, 2017).

The FarmFresh website illustrates some of the difficulties in developing a food asset map. For example, the website is cluttered and some of the information is outdated or limited.

Food asset mapping is becoming a useful visualization tool to analyze what resources a community contains for the purposes of increasing sustainability and food security. Many New England communities have begun implementing sustainability programs and could benefit from food asset mapping.

IV. Food Insecurity Case Studies from New England

Food insecurity is an issue that affects many areas across Massachusetts. Locations with low income residents and immigrant populations are particularly vulnerable to food insecurity. According to Massachusetts Food Trust Program (2017), "2.8 million people living in low income areas in Massachusetts lack access to grocery stores, including more than 700,000 children and 523,000 seniors." Access to grocery stores is further diminished due to supermarket owners preferring not to be located in such areas. Massachusetts has established programs such as the Massachusetts Food Trust Program, to combat the food insecurity. The Food Trust Program works closely with local organizations, farmers markets, and food trucks by providing them with grants, loans, and technical assistance. Lawrence and Springfield are among the top ten cities in Massachusetts where residents are faced with food insecurity (Massachusetts Food Trust Program, 2017).

Lawrence is located in Essex County, MA with a population of approximately 70,000 people (The City of Lawrence, n.d.). The city has a large number of immigrants and some people refer to it as the "Immigrant City" (The City of Lawrence, n.d.). Many working-class residents of Lawrence have financial difficulties that make it challenging to provide basic necessities for themselves such as food. Groundwork Lawrence is an organization that has been working to address this issue and create a more sustainable environment for the people of Lawrence. The objective of the organization is to "bring about the sustained regeneration, improvement and management of the physical environment by developing community-based partnerships which empower people, businesses and organizations to promote environmental, economic and social well-being" (Groundwork Lawrence, n.d.). To accomplish its mission, Groundwork Lawrence works with local farmers, schools and other organizations. Through community engagement, it has established food programs such as Groundwork Farmers Market and Schoolyard Garden. The focus of its programs is on "increasing access to high-quality fresh produce in Lawrence, enabling residents to make healthy food choices for themselves and their families" (Groundwork Lawrence, n.d.). Massachusetts has many similar communities working towards becoming more sustainable and increasing the food security of its residents.

Livewell Springfield is a collection of over 30 organizations in Springfield, MA focused on promoting healthy living. Two of its most impactful organizations are Fresh Mobile Farmer's Market (FMFM) and Just Food (JF). FMFM is an initiative that brings fresh food from Springfield farms to the people of Springfield. It visits several locations in Springfield and run on a schedule from July to October. FMFM is currently working on a new system that would allow them to take Supplemental Nutrition Assistance Program (SNAP) as a form of payment. The FMFM SNAP payment program is helping people make healthier choices by producing locally grown affordable products. In addition, JF has programs that seek to “create an equitable food system that would allow access to affordable, quality food for all in Mason Square [in Springfield]” (Livewell Springfield, n.d.). One of the most important objectives of this program is educating the residents about locally grown, healthy food choices. JF relies on community engagement in order to promote a sustainable environment. Different communities face unique challenges when promoting sustainability.

Martha’s Vineyard is a tourist destination with a distinctive food system because it is on an island and imports food to support its population. Island Grown Initiative was founded in 2005 to “help create a resilient and equitable food system on Martha's Vineyard” (Island Grown Initiative, 2017). Island Grown Initiative achieves its goals through community engagement. It educates people about eating and producing locally grown food and reducing food waste by redistributing it to those in need or for compost (Island Grown Initiative, 2017). Island Grown Initiative has worked on several projects to advance its agenda. The organization has started the “Reasons to Buy Local Food” campaign in order to engage the community in creating a more sustainable food economy. It is composed of three different stakeholders: Community Food Education, Food Equity and Recovery, and Farm Hub. The Community Food Education program works to involve the community in their local food system through training, workshops, and education. Food Equity and Recovery has a mission to reduce, recover, and recycle in order to diminish food waste and hunger in the community. In addition, Farm Hub works hand-in-hand with local farmers to educate and provide them with necessary equipment to grow as farmers. The program has harvested over 20,000 pounds of lettuce and 15,000 pounds of vegetables such as tomatoes, cucumber, herbs, and peppers (Island Grown Initiative, 2017).

Another organization concerned about food use on Martha’s Vineyard is the Island Food Pantry, which has been active for 35 years and has grown from one volunteer to more than 80. The number of families it supports varies based on the season. The pantry encourages clients to come in once every two weeks and is open for two hours three days a week. In 2016 the Island Food Pantry assisted 450 families, or about 1,000 people including an estimated 140 children (Hanjian, 2016).

Vermont Farm to Plate is dedicated to increasing the efficiency of the food system cycle throughout the state, and ensuring that no food is wasted and excess food is distributed to those in need. Vermont Farm to Plate accomplishes its mission by "source reduction, food rescue, composting, animal feed utilization and energy production" (Vermont Farm to Plate, n.d. a). The organization focuses on keeping food and other organic materials out of landfills, promoting food security, job creation, reduction of fossil fuels and greenhouse gas emissions, protecting natural resources such as water and soil, and building stronger communities centered around sustainable food system cycles (Vermont Farm to Plate, n.d. a).

To achieve its mission of strengthening Vermont's food system Vermont Farm to Plate has created many initiatives, including creating an entire training procedure for retail associates so it can better promote and sell local food (Vermont Farm to Plate, n.d. c). It has sponsored many case studies to see how to improve the current systems already in place. One such study was on the inefficiencies between meat producing and meat processing. It was widely believed by many organizations in the state that Vermont needed to expand the number of meat processing locations. Analysis revealed that the real issue was an inefficiency at the processing facilities caused by a particularly high demand during fall (Vermont Farm to Plate, n.d. b). Due to its size, Vermont Farm to Plate has the distinct advantage of being able to conduct research such as this to determine the best way to increase efficiency in local food system cycles.

Organizations like Vermont Farm to Plate help to promote food production, while aiming to decrease waste through a variety of methods. It helps to involve local communities to foster support and keep these programs going far past its initial creation. It is initiatives like these that look at food systems from multiple perspectives, trying to encourage the public to make an impact in their local communities.

During the 2008 recession, many small-town communities and food pantries began to feel the strain from the economic downturn. One such town was Rutland, VT. It began to find that it did not have enough food in its food pantry and therefore struggled to support its community during difficult times. However, by implementing more sustainable practices such as gleaning, the local food pantry was able to relieve some of the pressure felt by the community (Vt. Embraces Gleaning as Way to Reduce Hunger, 2014). *Gleaning* refers to the agricultural practice of going through fields after the initial harvest and picking up any food that remains or may have fallen to the ground that would otherwise end up being wasted. This practice not only benefits the community by providing more food, but it also helps the farmers because most farmers do not want excess food creating unnecessary biomass in their fields (Vt. Embraces Gleaning as Way to Reduce Hunger, 2014). Vermont farms such as the Duchess Farm are allowing volunteers to glean its fields after the initial harvest to bring the food to local food pantries and low-income families. Just from this one small town's efforts, it is estimated that 15,000 pounds of food were recovered through gleaning alone (Vt. Embraces Gleaning as Way to Reduce Hunger, 2014). This shows that even small changes can have large effects in a community.

A common theme observed among these organizations is an effort to engage the community with new initiatives and to promote mindful living. Organizations focused on sustainability help transform communities to become food-minded and raise the overall food security through food pantries. There are many commonalities between sustainable communities; most notable, perhaps, is community involvement to improve access to locally-produced and sustainable food, as well as the implementation of policies that help to promote this (Garnett, 2013, p.1). Food loss is a key aspect of food sustainability, and can spark community organizations' focus. Looking at other organizations and comparing their situations to Nantucket's provides an idea of what type of data to look for in building a food asset map.

V. Nantucket Food System Cycle

In the following section, we focus on the food system in Nantucket. We first describe farming, then aquaculture, and finish by discussing the sustainable practices and organizations on the island.

- Farming on Nantucket

Nantucket is an island off of Cape Cod, MA with a unique food system. The island is a summer tourist destination, with seasonal residents. To feed the fluctuating population on Nantucket, food is imported onto the island and also locally grown. About half the island is now in conservation (Nantucket Land Bank, 2017); the remainder of Nantucket, according to Nantucket realtors J Pepper Frazier (2017), is "closely monitored by a group of boards" with historic preservation and public enjoyment in mind, leaving relatively little room for agriculture. Only about 1% of Nantucket's land is used for agriculture: about 630 out of 67,360 acres. A GIS map of land use in Nantucket is shown in Figure 7. The light green area is land being used for agriculture; this does not include cranberry bogs (bordered in orange).

Figure 7: Nantucket Town GIS Screenshot of Land Use Areas (MapGeo, 2017).

In 1850, there were more than 100 farms on Nantucket (Nantucket Land Bank, 2016). However, farming began to decline when the whaling industry collapsed and the population on Nantucket decreased sharply from about 10,000 in 1850 to 4,000 in 1870 (Oldham, n.d.). Today, there are only 14 farms on the island.

Bartlett's Farm is the largest farm on the island and a proponent of sustainable agriculture. Bartlett's Farm has a long history on the island, beginning in the early 1800s. It is now on its sixth generation in the Bartlett family (Bartlett's Farm, 2017). They own 125 acres of land, most of which is highlighted by a yellow box in Figure 8. Vegetables from the farm are served in many Nantucket restaurants, and their flowers occupy gardens and window-boxes throughout the island (Bartlett's Farm, 2017). Other sizable farms on the island include Moors End Farm and Pumpkin Pond Farm. For more details on Nantucket's farms, see Appendix A.

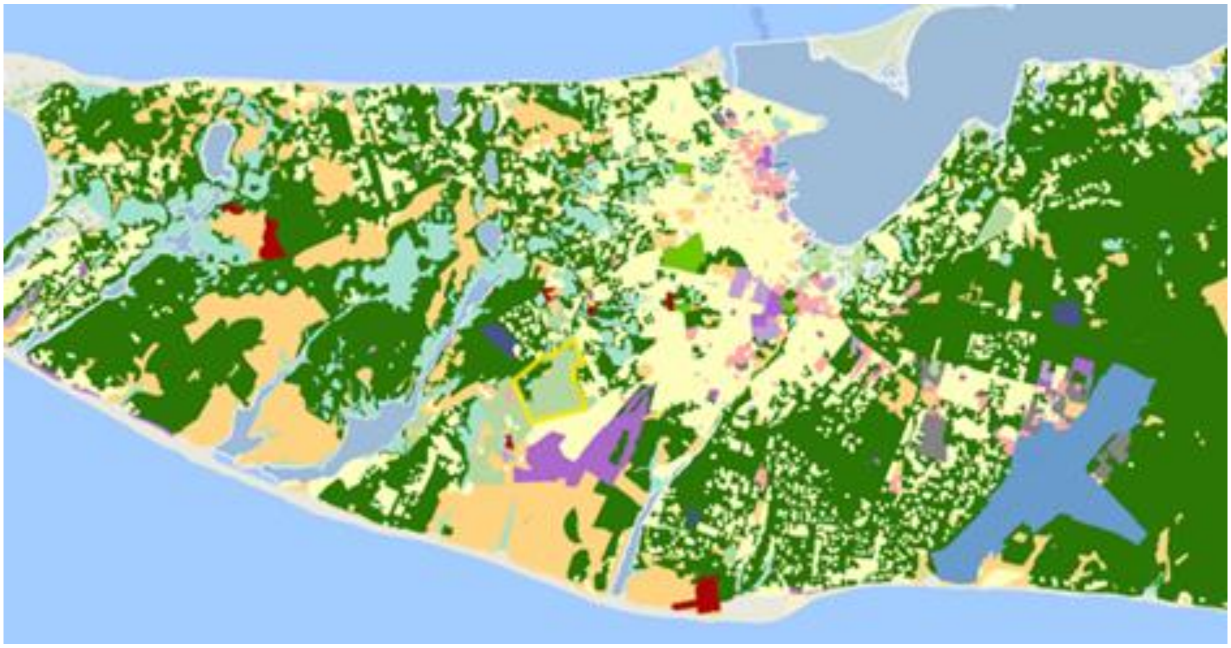

Figure 8: West Side of Nantucket Island Highlighting Bartlett's Farm (MapGeo, 2017).

Milestone Cranberry Bog and Windswept Cranberry Bog are the two cranberry bogs on Nantucket owned by the Nantucket Conservation Foundation. According to the Nantucket Conservation Foundation (n.d. a), Milestone Bog now only cultivates 50 of their195 acres. Windswept Cranberry Bog operates on 37 acres of land bringing the total area of cranberry bogs on Nantucket to about 87 acres, which was previously 230 before Milestone Bog began organic farming methods. The green circle in Figure 9 highlights the Windswept Cranberry Bog and the blue circle highlights the Milestone Cranberry Bog.

Figure 9: Windswept and Milestone Cranberry Bogs on the Nantucket Conservation Foundation map (Nantucket Conservation Foundation, n.d. b).

When Milestone Cranberry Bog was larger it had the potential to produce up to 2 million pounds of berries per year (Nantucket Conservation Foundation, n.d. a). This has been greatly reduced since the bog is now only operating on 50 acres in an effort to compete with organic cranberries from Canada (Stanton, 2017). Only a small amount of the cranberry harvest is sold locally; the majority of these berries are exported and sold to large fruit companies such as Ocean Spray, Decas, and The Power of Fruit (Cocuzzo, 2015).

Cranberry sales fund the Nantucket Conservation Foundation projects and initiatives. To keep up with Canadian cranberry competition in hopes "that the fiscal savings associated with not farming those 140 acres, coupled with inroads into the health-food market with organic berries, will allow the bogs to at least break even", both Milestone and Windswept Cranberry Bogs began using organic farming methods (Stanton, 2017). The Nantucket Conservation Foundation hosts the cranberry festival annually to educate the community and promote cranberry produce (Cranberry Festival, n.d.). For more information on Nantucket's cranberry bogs, see Appendix B.

- Aquaculture on Nantucket

Aquaculture also plays a role in the Nantucket economy, although much less today than in the past. There is an active aquaculture area of 30 acres in the Nantucket Sound for blue mussels, and also an oyster farm at the entrance to Polpis Harbor which has been active since 1980. For details on oyster farms and their locations, see Appendix C. Another proponent of aquaculture is the Brant Point Shellfish Hatchery. This facility raises bay scallops to support the scallop population in the Nantucket and Madaket Harbors (Brant Point Shellfish Hatchery, 2015).

Bay scallop fisheries are significant not only in Nantucket, but nationally. Scallops used to range the coast from North Carolina to Maine, but today their populations are severely depleted (Nantucket Shellfish Management Plan Committee, 2012). Nantucket's bay scallop fishery is still functioning today, but is less productive than it once was. According to the Nantucket Shellfish Management Plan Committee (2012), there is a lack of public "concern for the future of the resources and the habitats supporting them." Thus, the Shellfish Management Plan was created in 2012 to be implemented in the Nantucket and Madaket Harbors. Its goals are to maintain or improve the habitats with a healthy shellfish fishery, and maintain or enhance the shellfish populations in the Nantucket waters (Nantucket Shellfish Management Plan Committee, 2012). One way proposed to manage growing areas is requiring licenses for aquaculture.

Shellfish aquaculture licenses allow people to plant/raise shellfish, use protective devices on tidal flats (like boxes, trays, nets), harvest/take legal shellfish, plant cultch to catch shellfish seed, and grow shellfish using racks, rafts or floats (Nantucket Shellfish Management Plan Committee, 2012). The Shellfish Management Plan recommends the encouragement and support of aquaculture by increasing available space and use of space in the waters and continuing to identify potential aquaculture locations. Recently, shellfish aquaculture has been growing in acres farmed, especially in the northeast of the island, at a rate of about 10% per year (Nantucket Shellfish Management Plan Committee, 2012). This is one source of locally grown food that can be and is very successful within the Nantucket food system.

➢ Promoting Sustainable Agriculture on Nantucket

Several organizations have been advocating for more sustainable agriculture and food production on the island, including Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket. Sustainable Nantucket is focused on promoting sustainable agricultural production on the island. Its mission is “to preserve the community character of Nantucket while sustaining its economic and environmental vitality” (Sustainable Nantucket, 2017a). Sustainable Nantucket aims to expand agricultural demand and production, to educate the community about sustainability, and to increase access for the community to local food through farmers markets, restaurants, and schools.

Four major programs Sustainable Nantucket leads are the Farmers & Artisans Market, Farm to School, Community Farm Institute, and NantucketGrown™.

- *Farmers & Artisans Market:* In 2007, this event was started to raise awareness of local growers and keep downtown Nantucket connected to the community. Everything sold at the market is grown/produced on the island.
- *Farm to School:* This program bridges the gap between schools and local farms. It is partnered with the Nantucket Public Schools Food Services Department and Food Rescue Nantucket with the aim to serve healthy meals in school cafeterias by “building a school garden for education and supplementing school food supply” and supporting local and regional farmers (Sustainable Nantucket, 2017b).
- *Community Farm Institute (CFI):* The Walter F. Ballinger Educational Community Farm, also known as CFI, is a community farm that teaches new farmers sustainable farming practices. Growers start with an eighth of an acre and as they learn more, they can graduate to larger plots of land. It was founded in 2000 and through the Land Use Partnership Initiative and

Agricultural Apprenticeships, Sustainable Nantucket works to provide classes, workshops, and resources for education (Sustainable Nantucket, 2017c).

- *NantucketGrown™:* To expand the market and access to local food, the Nantucket Grown Campaign began. This campaign works to promote the NantucketGrown™ brand to provide farmers, restaurants, and food producers with an "instantly recognizable branding campaign" to show consumers that their food came from Nantucket (Sustainable Nantucket, 2017d).

In spite of being a resort community, Nantucket has many individuals on the island who cannot make ends meet and need assistance in feeding themselves and their families. The Nantucket Food Pantry and Food Rescue Nantucket work hand-in-hand to promote a more equitable and sustainable food system. The Food Pantry on the island regularly supplies food to about 200 families in the summer and 100-125 families in the winter, and has a mission to "provide food on temporary basis to persons with no income or inadequate income to feed themselves and their families" (Nantucket Food Pantry, 2011). In addition, the Food Pantry has goals to strengthen the availability of healthy foods, to work with local initiatives to maximize local food assets and end hunger on Nantucket, and to share tools such as local food asset maps with the community (Nantucket Food Pantry, 2011). In 1995, it started a program that has evolved in association with Sustainable Nantucket to become *Share Your Harvest* that involves individuals, families, and group gardeners to supply fresh produce (Nantucket Food Pantry, 2011). The idea is to make sure local fruits and vegetables are available for Food Pantry clients, which also helps to reduce fresh food waste and spoilage. Since the start of the program, "over 20 million pounds of produce providing over 80 million meals have been donated" (Nantucket Food Pantry, 2011).

Food Rescue Nantucket is "a Nantucket Unitarian Meeting House congregational initiative in partnership with the Food Pantry of Nantucket" with the goal of no food being wasted (Food Rescue Nantucket, 2017). It collects fresh foods and then redistribute them using the Nantucket Food Pantry network in order to reduce food waste. The amount of food going to waste on Nantucket is unknown. We do know, however, that every year in the United States 30-40% of food produced ends up as waste in landfills (United States Department of Agriculture, n.d.). To combat Nantucket's food waste, Food Rescue Nantucket has collected and distributed more than 10 tons of food over 2 years (Gary Langley, personal communication, September 22, 2017). About 80% of the food comes from Bartlett's Farm, and other regular pickups include: The Bean, Something's Natural, Moors End Farm, Fast Forward, and more (Gary Langley, personal communication, September 22, 2017). The food is distributed to various locations, mostly to the Food Pantry. Collaborating with the Food Pantry, Food Rescue Nantucket also picks up food from restaurants on the island when they close for the season. Food Rescue Nantucket and the Food Pantry work together towards the efficient use of food on the island.

VI. Conclusion

The rise of sustainable agriculture, prompted by environmental and ethical concerns, is shining a light on food issues in communities. Food security is a growing problem for many people on Nantucket and organizations such as Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket are exploring a variety of ways to address this issue. Mapping food assets would allow Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket to evaluate the aspects of the food system cycle, identify areas to expand their food network, and help educate and engage the community so that a more sustainable food system can be developed on the island.

Methodology

The goal of this project was to develop an interactive food asset map and database for Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket to identify areas to expand food production, improve food distribution to recipients, and reduce food waste on Nantucket. This was done by following five objectives:

1. Identify and evaluate best practices in the development of food asset maps and databases
2. Clarify details of the purpose, content, and format of the food asset map and database with respect to the goals set forward by Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket
3. Build a food asset map and database
4. Use the food asset map to analyze Nantucket's food system (production, distribution, consumption, waste) in order to identify opportunities for improvement
5. Integrate the food asset map with existing programs and develop a strategy to update and maintain the map and database

These objectives involved a variety of tasks including interviews with stakeholders and the assessment of ArcGIS and other databases, in addition to site visits and observations, as illustrated in Figure 10. We describe these tasks in more detail below.

Figure 10: Flowchart for Objectives and Tasks.

Objective 1: Identify and evaluate best practices

Before beginning the project, we needed to learn: What information is gathered and how is it displayed in food asset maps and databases, what platforms are typically used, how these maps and databases are used to analyze and improve food systems. To approach these questions, we reviewed pertinent literature and supplemented this background research with a set of interviews with experts on food asset mapping and Nantucket land use (see Figure 11).

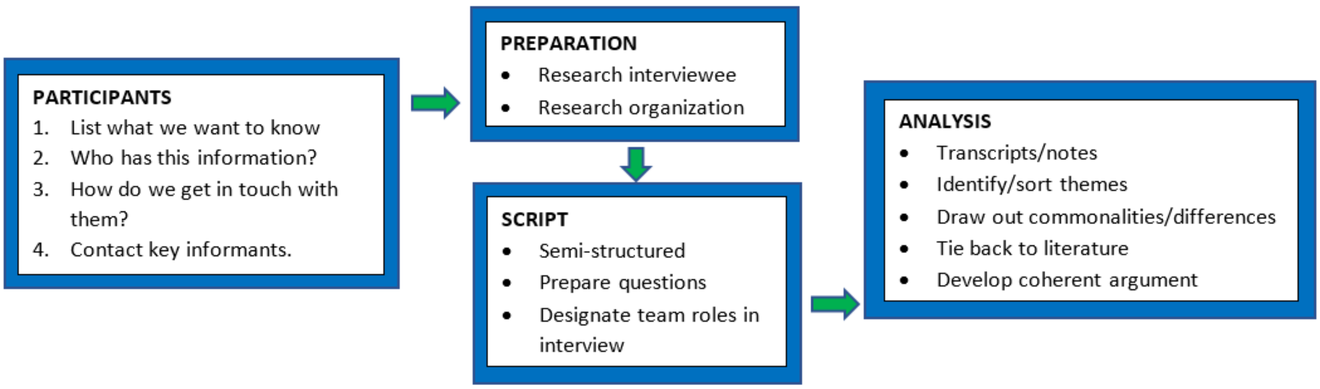

Figure 11: Flowchart of Interview Process.

We conducted semi-structured, qualitative interviews by phone and in person, with one team member taking notes. We did not need verbatim transcripts so key themes were noted with selective quotations. We developed the interview questions based on our background research and feedback from our advisors and representatives from Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket. A preamble was emailed to the interviewee in advance and repeated at the beginning of the conversation (see Appendix D).

Since there are relatively few food asset maps, we found one extensive large-scale example of Maryland. We interviewed a creator, GIS Specialist Jamie Harding from Johns Hopkins Center for a Livable Future, about this map to gain useful information about mapping platforms.

We conducted an interview with the assistant director of the Nantucket Islands Land Bank, Jesse Bell, who gave us information about the Nantucket Islands Land Bank mission towards agriculture, open space programs, and land that is open with the potential of being transformed into an agricultural use. To gather more information about practices on Nantucket, we interviewed Jeff Carlson from the Nantucket Natural Resources Department to learn about the Shellfish Management Plan, and also active and open sites of aquaculture on the island.

These three interviews were useful in the compiling of data to assemble the database of the food asset map, and also for learning about the most suitable GIS map format and platform to display our data.

Objective 2: Clarify ideas for food asset map

Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket have minor differences in their needs and expectations for Nantucket's food system, but their overall missions are similar. This is the first project on which these organizations are working together so we scheduled regular meetings to understand their individual ideas and build consensus around their common goals. We discussed their expectations in terms of the content, features, and format of the map and associated databases. Using the research proposal as a point of departure, we met with them to discuss details such as:

- What types of food assets should/should not be included in the database and associated maps?
- Where the map should be hosted?
- How would the map and database be used in the future?

Our initial discussion involved what types of food assets should go onto the map. We started with our given list and presented a base map with that information. After viewing this map and talking with them more, we added data layers specific to each organization's individual interests.

In regards to where the map should be hosted, the organizations agreed that the best-known organizations, Sustainable Nantucket and Food Rescue Nantucket, would include the map on their websites. This would provide the greatest reach to the community and those involved in the food network.

To judge how the map and database would be used in the future, we talked individually with each organization to gain an understanding of what their long-term and everyday objectives were. After gaining this understanding, we began the creation of our food asset map and database.

Objective 3: Build a food asset map and database

To begin the process of building a food asset map, a listing of food assets on Nantucket was created:

- Producers (farms, apiaries, & florists)
- Farms (smaller section of producers; just agricultural farms)
- Areas of Aquaculture
- Distributors (grocery stores, distribution facilities, & convenience/liquor stores)

- Storage (dry, freezer, & refrigeration facilities)
- Restaurants
- Lodging (Inns & Hotels)
- Caterers
- Commercial kitchens (hospital, schools, churches, & human service agencies)
- Waste facilities

We identified information fields of interest for each asset, including:

- Name
- Owner
- Locations
- Type of asset
- Contact information

The asset data was compiled on Google sheets from sources such as:

- Online searches
- Nantucket phone book
- Nantucket restaurant guides
- Sustainable Nantucket's NantucketGrown™ list
- Sustainable Nantucket
- Nantucket Health Department commercial kitchen information
- Nantucket Chamber of Commerce website
- Food Rescue Nantucket

To gather information such as: dates/seasons of operation, distributors they use, interest in composting, and willingness to participate in donating extra food to the Nantucket Food Pantry, we conducted a restaurant survey. We sent the survey to approximately 85 local restaurants; we obtained 14 responses (see Appendix E for survey preamble and questions). Although we did not get enough responses to warrant survey results, we followed up on some interesting trends by interviewing restaurant owners and managers.

After gathering all the data on Google Sheets, we utilized an add-on called Awesome Table in order to convert all the addresses to longitude and latitude to plot the locations. The spreadsheet was downloaded to a computer desktop as a CSV file and uploaded on ArcGIS online to generate the food asset map. This process is illustrated in Figure 12 below.

Figure 12: Database Transfer and Map Creation Flowchart.

- Map Evaluation

After the database was assembled, through discussions and research we evaluated different platforms to be used for the map. The first option was using Google Maps for the display of our data. There are benefits to using Google Maps; such as user-friendliness of the platform's interface. Google Maps provides a quick and easily accessible way of displaying point data. Point data is a single point that can be located on a map using a longitude and latitude coordinate system. With all the features of Google Maps, there are also some limitation with the platform. Options for displaying non-point data on Google Maps are not as comprehensive as for other platforms.

The other platforms investigated were ArcMap and ArcGIS Online. ArcMap is an expansive desktop mapping platform that provides its users with many options on creating, publishing, and displaying data on a map. In contrast to Google Maps, ArcMap allows a user to plot more than just point data. The complexity of the ArcMap platform presents the main challenge for this platform. Navigating through this platform is difficult and requires considerable training. The features on this platform include plotting point data and parcel data, highlighting certain areas and displaying information. ArcGIS Online is a derivative and more user-friendly version of ArcMap.

ArcGIS Online is simpler, but it supports features that are an integral part of the project, such as the ability to create an online map, import data layers onto it, and make the map accessible to the community. The publishing features are versatile, including the option of creating a web application from the map. Navigating through ArcMap requires some experience working with complex software, whereas ArcGIS Online does not require a high technical skill to use. ArcGIS Online can be learned more quickly while ArcMap takes more self-training and tutorials to accomplish the same basic tasks. This makes it suitable for updating in the future because the skill-level required is not as high.

Objective 4: Use the food asset map to analyze Nantucket's food system (production, distribution, consumption, waste) in order to identify opportunities for improvement

To approach this objective, we created a few questions to answer:

- How did each organization wish to use the map?
- What additional information did they request?
- Should all of the information in the database be publicly accessible? If not, how would that be handled?
- How can the map be used to promote the objectives of each organization?

Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket had specific goals in mind for the project, so we addressed all of their interests. We worked to identify additional opportunities for the food network on the island with the resources we gathered and through visualization with the food asset map.

To provide the organizations with the resources necessary to identify inefficiencies and food waste in the food system cycle on the island in order to help eliminate them, we aimed to identify key attributes that could be beneficial for this goal, as listed in Objective 3. With all of this data clearly mapped out we began to analyze the food system and draw conclusions. In addition to the preliminary food asset layers, we expanded the map to include data layers such as:

- Areas of Aquaculture
- Food-focused organizations

These layers map out places that could be further enhanced to promote each of the three organizations' goals. They also help to create a more complete database of food-related information.

Objective 5: Develop a strategy to update and maintain the food asset map and database

We developed a strategy to update the map and database regularly to ensure it does not become outdated and obsolete. Due to the fact that Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket are relatively small nonprofits, the time and resources they have are limited. This coupled with the fact that they do not have employees familiar with GIS software makes it unlikely they will want to assume the task of updating and maintaining the map. However, we wanted to keep the updating of the map local and we researched alternatives. We learned of the existence of student groups at Nantucket High School interested in sustainability and in information technology. After talking with the teachers/advisors of these student groups, we decided to start a program at the

Nantucket High School to get students involved in updating the database. We worked with the High School to teach interested students how to use the software and how to update the online map and database. This was an opportunity not to just to update the map but to better promote education in sustainability and establish a better relationship between Sustainable Nantucket, Nantucket Food Pantry, Food Rescue Nantucket and a younger generation of environmentally concerned people. We additionally created a user manual to help future high school or WPI students learn how to update and maintain the map in an effort to keep the map current. To view the manual, see Appendix F.

THE FOOD SYSTEM ON NANTUCKET

In the following chapter, we present the Nantucket food asset map and its associated database created for Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket. This map is the first step in a Comprehensive Food System Assessment that will take a few years to complete. The purpose of this map is to create a database that will consolidate all the information on the current food system cycle and spark changes to improve the system. We subsequently analyze the map in regards to Nantucket's food system and list our observations. Then introducing the map and database, we explain the format of the map and the update plan to keep the map current.

Food System Cycle

The Nantucket food asset map contains a comprehensive list of food assets including production, distribution, consumption, and waste. After discussion with Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket we determined what information would and would not be publicly available. This includes Food Rescue Recipients, information obtained through the restaurant survey, and producers who do not wish for their information to be publicly available. These data layers with confidential information will be created as private data layers and only Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket will have access to these. Thus, we have chosen to omit those layers from our final report. What follows is the data layers that will be publicly accessible from the host website, Sustainable Nantucket.

- Production

We found the most accurate representation of producers on Nantucket to include: apiaries, florists, farmers, oyster farmers, fisherman, and other select producers. A few small producers only source to restaurants and elected to keep their addresses hidden. Figure 13 shows all public producers on Nantucket in black diamonds.

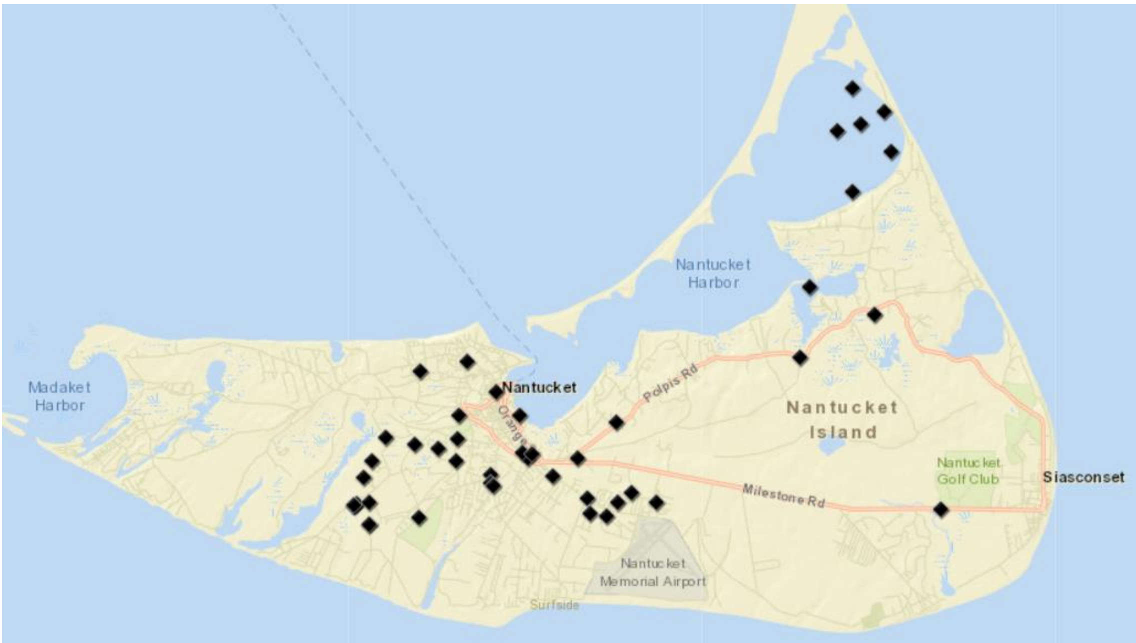

Figure 13: Producers on Nantucket.

There are 47 producers mapped with the majority being concentrated in the center of Nantucket. There are 16 agricultural farms shown in Figure 14 in green rectangular points. Farms are on both Madaket and Siasconset sides of the island, with the primary number of farms located on the Madaket side of the island. More information about Nantucket's farms can be found in Appendix A.

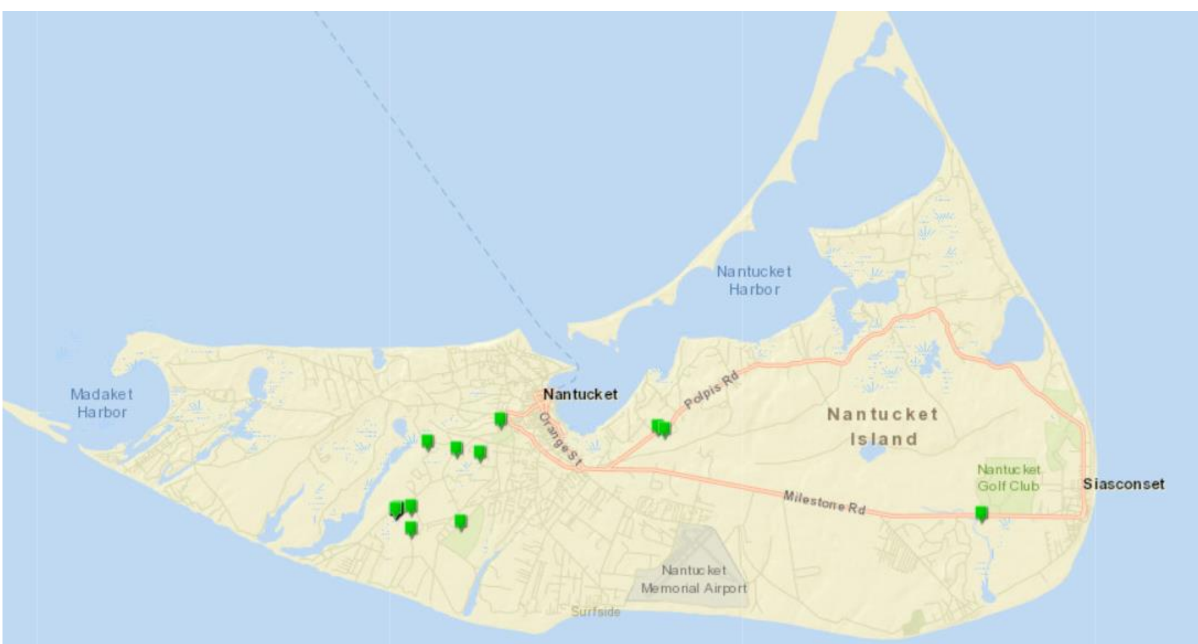

Figure 14: Farms on Nantucket.

These farms are located away from the downtown area, where most food consumption occurs. This requires farms to deliver food to the restaurants, adding extra transportation efforts from the producers.

Food Rescue Nantucket transports excess food from select farms, restaurants, and groceries to many locations including the Nantucket Food Pantry. Since Food Rescue Nantucket does not pick up from every location on the island with excess food, there is opportunity for Food Rescue Nantucket to reach out to more food locations. The map can help Food Rescue Nantucket identify these producers to enhance their waste reduction efforts and promote gleaning programs.

Although gleaning is already practiced through individual and organizational efforts, not all farms and producing locations are practicing it. Food Rescue Nantucket has a current gleaning initiative with the Sustainable Nantucket Farm to School program that donates gleaned food from Moors End Farm and Bartlett's Farm to the Nantucket schools. Excess food from this program gets donated to the Food Pantry. The gleaning season runs from August to early December. More promotion can be done to reach out to farmers to make them aware of the volunteers willing to glean their fields.

The *Share Your Harvest* program only involves small backyard food producers on the island. This could be expanded to reduce future food waste from a greater number backyard gardens with increased promotion and outreach. Since Food Rescue Nantucket is interested in reducing food waste, it can work with the Food Pantry on its *Share Your Harvest* program to transport food from the backyard gardens. This could encourage participation in the program and connect Food Rescue Nantucket to owners of large backyard gardens for potential gleaning opportunities in the future.

Potential area for production expansion

One major restriction in Nantucket's food production is the lack of land available for agricultural use. There are a couple of contributing factors to this issue, one of which is the high price of land on the island. In addition, 50% of the land on the island is in conservation, while less than 1% of the land is currently being used for agriculture. The expansion of agriculture could lead to significantly more food being produced on the island and this would supplement the food being imported on to the island to increase Nantucket's sustainability. We discussed the criteria for land expansion with Sustainable Nantucket to gain a clear understanding of what makes the land suitable; potential land must have been used for an agricultural purpose in the past 15 years. This is because it is less likely that there are endangered plants on the land if it has been used agriculturally in the past 15 years; this includes: mowing, sheep grazing, and other agricultural processes. There are other factors including wetlands protection and open space restrictions that would need to be evaluated before final purchase.

During an interview with Jesse Bell, Assistant Director of the Nantucket Islands Land Bank, she mentioned that expanding agriculture on the island is a part of the Nantucket Islands Land Bank's mission. She felt that their agricultural goal was an area of its mission that the Land Bank could improve upon henceforth. The Land Bank has previously worked positively with Sustainable Nantucket on implementing their Community Farm Institute, and look forward to continuing their partnership with Sustainable Nantucket in the future.

We have also found aquaculture to be another source of production on the island to look at expanding. In conversation with Jeff Carlson of the Nantucket Natural Resources Department, we found that the areas surrounding Nantucket, along with the harbors, are used for commercial scalloping from November 1 through March 30. The Brant Point Shellfish Hatchery is on island, where adult bay scallops are harvested from the harbor, brought to the hatchery, and bred. The larvae are then released into the wild to rejoin the native population, which keeps the scallop population steady in the region. The only prohibitions for scalloping are the reserved aquaculture areas, where there is a lack of scallops and other shellfish are present.

Aquaculture occurs around the island by private growers and by the town, occupying about 100 acres of land altogether. The town allows a maximum of 10 acres of land to each grower by lease. All growers are required by the town to renew their lease/license every three years to ensure all active spaces are in fact being used. Regions of aquaculture around the island include: Coskata Pond, Polpis Harbor, Head of the Harbor, and Pocomo Meadow Area. These are featured in Figure 15. Information about these areas is managed by the Natural Resources Department, which noted there are unoccupied leases on Polpis Harbor that the town has reserved as extra space for potential expansion (circled in blue on the figure).

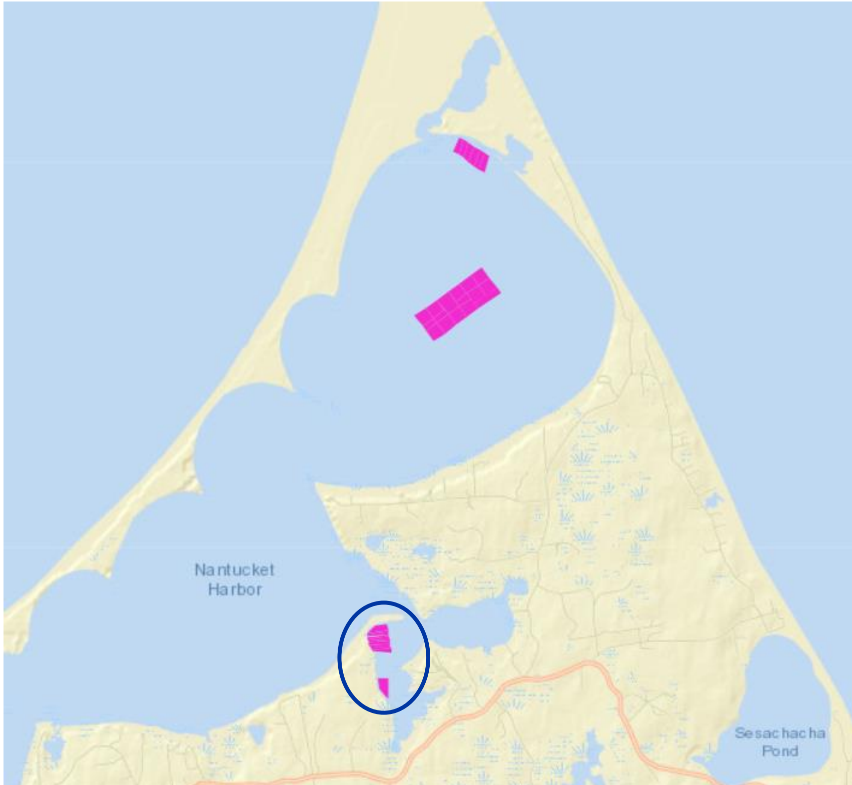

Figure 15: Aquaculture Locations around Nantucket.

- Distribution & Storage

There are 43 on-island distributors and 13 off-island distributors. Figure 16 shows the distributors on Nantucket while Figure 17 shows the distributors on and off island in orange squares. Distributors are scattered throughout the island with a concentration in the downtown area and are primarily small grocery and convenience stores. Distributors off island are primarily large food distribution facilities that range from New Jersey to New Hampshire, with the majority being located in Massachusetts. Off island producers import the vast majority of the food on island, mainly through the use of the Steamship Authority ferry. This can present challenges when there are high winds or storms and the ferries are cancelled for several days, interrupting the island's main food supply.

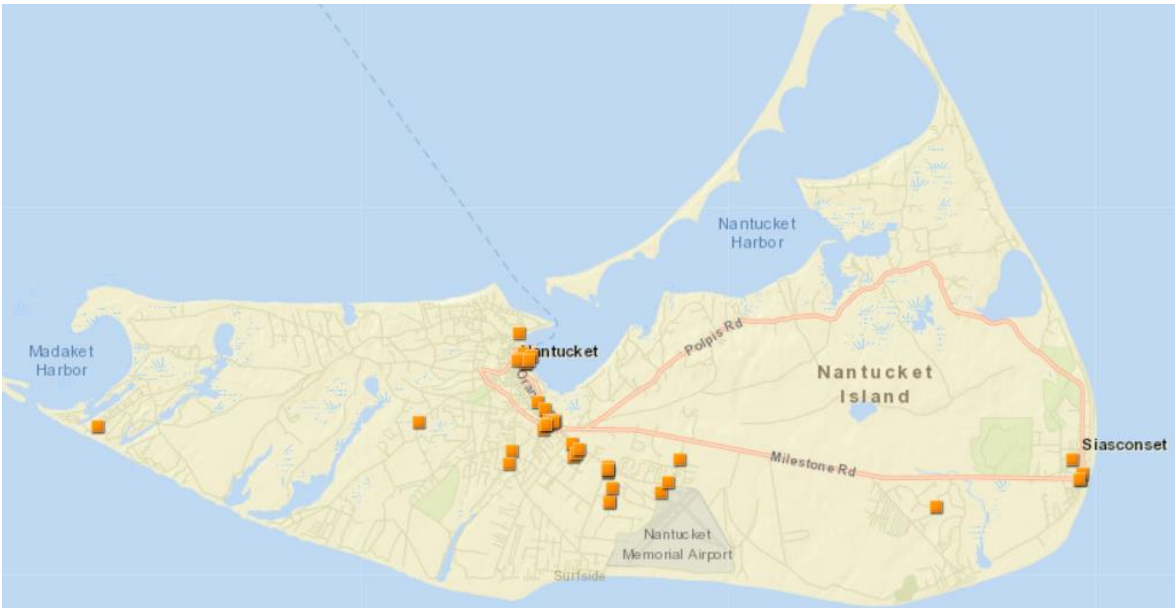

Figure 16: Distributors on Nantucket.

Figure 17: Distributors off Nantucket.

Figure 18 shows the storage facilities for food on the island. There are 16 in total including freezers, refrigerators, Food Pantry storage locations and Food Pantry and Food Rescue Nantucket drop off locations. Locations with freezers and refrigerators include the Food Pantry and Sustainable Nantucket. These locations are extremely valuable because they allow these organizations to store perishable foods; however, there are very few locations with available refrigeration and freezer capabilities. Expansion on this could greatly improve the amount of perishable foods that could be stored. Some of these drop off locations for the Food Pantry include Stop and Shop, Living Faith Church, Nantucket Cottage Hospital, St. Mary, our Lady of the Isle Catholic Church, Unitarian Universalist Church, St. Paul's Episcopal Church, Summer Street Church, Nantucket United Methodist Church, and First Congregational Church. The Food Pantry is still faced with a unique challenge of trying to import enough food from the Greater Boston Food Bank with the added challenge of having to transport food over the ferries. So while they have many drop off locations and food donations from on island, they are always looking to expand any opportunities for this.

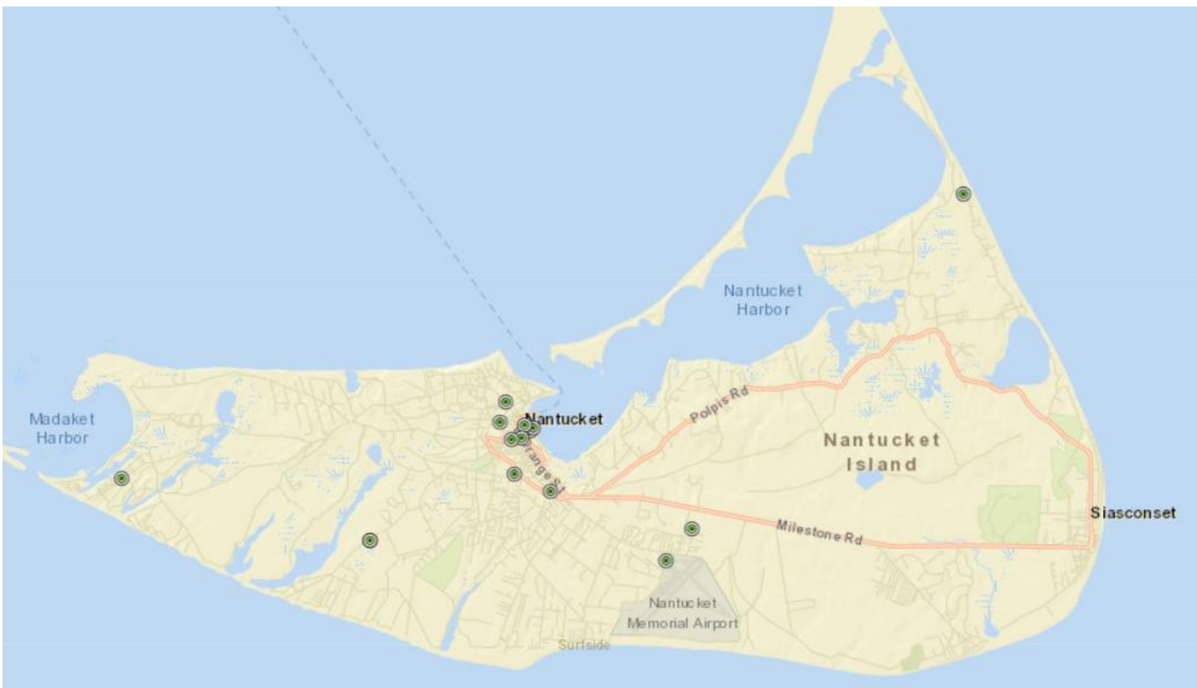

Figure 18: Storage on Nantucket.

Nantucket's situation for food storage is unusual due to the fact that it is an island with limited space. Transportation is more expensive, less reliable, and takes more time than in areas on the mainland. This stresses the importance of having more locations on the island that store and preserve food.

The Greater Boston Food Bank is the main source of food used by the Nantucket Food Pantry, about 85%. However, the Food Bank only delivers to Harwich, thus requiring an extra step in transportation to get the food onto the island via ferry. The Food Pantry transports perishable items with the use of a refrigerated truck, and they are partnered with Cape Cod Express in order to transport the nonperishable items to Nantucket. The ability to provide more food is hindered by the lack of space and extra steps of importing food onto the island.

One popular program between libraries and food distribution organizations is called *Food for Fines*. This program involves exchanging non-perishable foods for a reduction in library fines. *Food for Fines* is a particularly popular method of payment at Worcester Polytechnic Institute. A student who has an overdue fine at the WPI Gordon Library can give non-perishable food items in exchange for a $5 fine reduction per food item. The donation cannot be expired or in a glass container to be accepted. This program began in 2014, and Table 1 shows, for the following years, how much food was collected, the value of the food, and the number of donations. The food gets donated to food banks throughout the Worcester area and the Gordon Library partners with WPI affiliated organizations throughout the year. (Amy Lawton, personal communication, December 6, 2017).

Year	Cans Collected	Food Worth	Number of Donations
2014	171	$650.20	41
2015	607	$2,358.69	136
2016	909	$3,413.10	227
2017 (up to May)	333	$1,112.75	111

Table 1: Gordon Library, Food for Fines (Amy Lawton, personal communication, December 6, 2017).

➢ Consumption

Nantucket food consumption has areas for improvements in the reduction of its food waste. Many commercial and private locations of Nantucket already implement sustainable food practices with some restaurants producing little to no waste. However, there are numerous Nantucket restaurants, inns, hotels, caterers, and commercial kitchens where food waste can be reduced, food can be donated, and kitchens can be utilized or rented during off-times. Figure 19 shows the restaurants on Nantucket in purple dots, and lodging in black dots. There are 159 total Nantucket restaurants pictured, along with 30 locations of lodging. Most of these establishments are located in the downtown area with a few scattered restaurants on the far sides of the island. Figure 20 shows the drop-down information available when selecting a restaurant location, using the Boarding House as an example. Information such as their NantucketGrown™ certification is displayed as well as contact information. This can be used in the future to contact restaurants about their food waste to help implement sustainable programs.

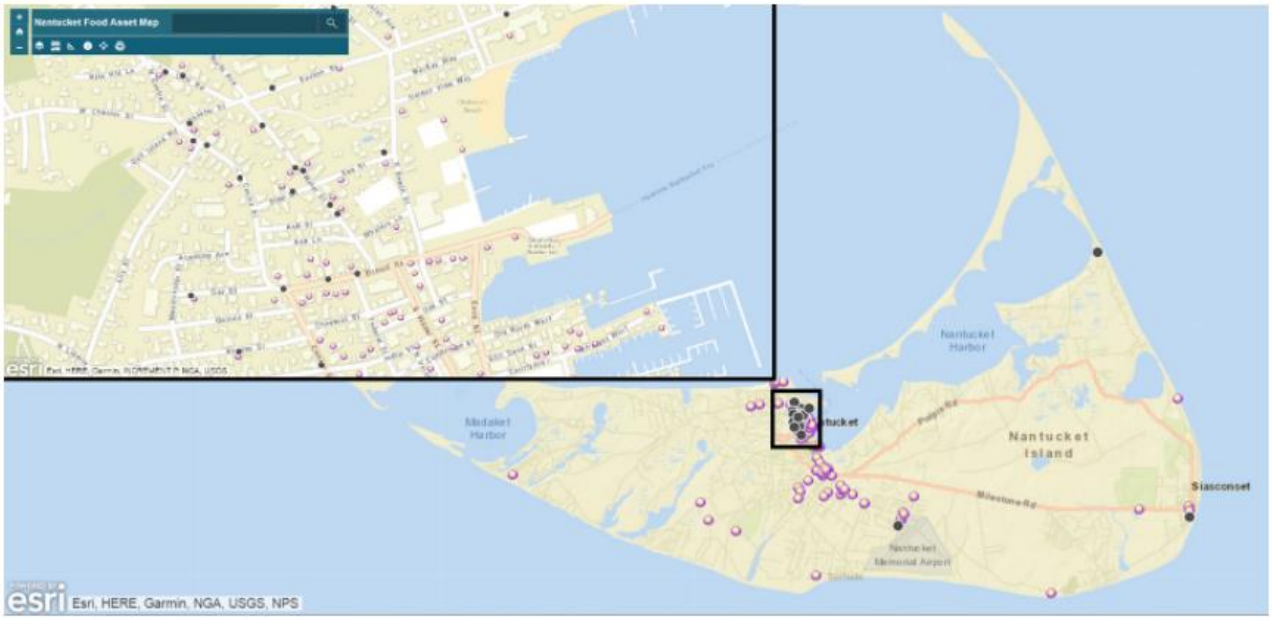

Figure 19: Restaurants and Lodging on Nantucket.

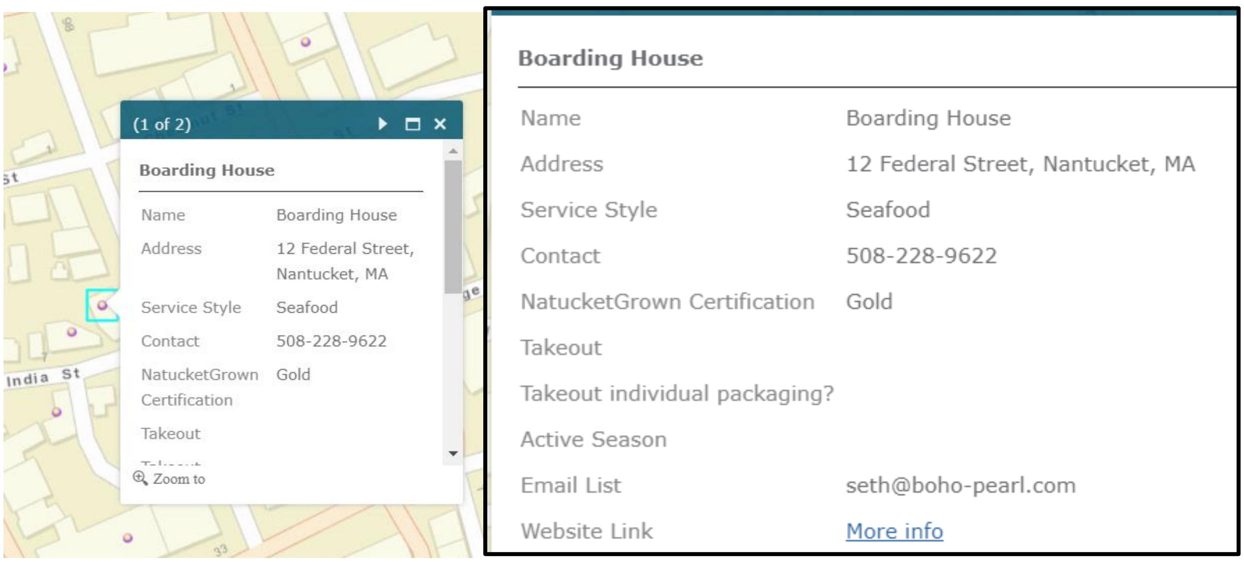

Figure 20: Pop-up Dialogue Box for the Boarding House.

Nantucket has a strong connection to consuming and marketing locally produced food, with NativMade and Sustainable Nantucket's NantucketGrown™ brand being notable examples. However, only 30 out of 159 restaurants are recognized for sourcing locally. In Table 2, the NantucketGrown™ certification level and the number of restaurants associated with that level is shown. Gold level restaurants source about 30+% of their food locally, silver sources about 16-29%, and bronze sources about 5-15%.

	NantucketGrown™ Certification Levels			
	Gold	Silver	Bronze	None
Number of Restaurants	14	10	6	129

Table 2: NantucketGrown™ Certification Levels.

In an interview with Chef Bruce Sacino of the Westmoor Club, a gold level certified NantucketGrown™ restaurant, he expressed that he believes customers appreciate knowing their food was grown locally. However, there are some barriers to sourcing locally because some foods are not produced on Nantucket and need to be imported to meet customer demands. Local sourcing helps reduce food waste by eliminating long-distance distribution.

Another opportunity to eliminate food waste is to contact caterers about their food usage. The food asset map has contact information for caterers around the island. Figure 21 shows the locations of caterers on Nantucket in yellow flags. There are 27 caterers included. The caterers follow the same location trend as restaurants with the largest proportion being located in the downtown area.

Figure 21: Caterers on Nantucket.

We found that the Nantucket Food Pantry's capabilities are confined in terms of the kinds of assistance it can give to its clients due to its limited space. It can only accept pre-packaged items with ingredients labeled, since it does not have a location that could be used for repackaging other donated foods. Because of the high cost of land, it is not feasible to expand to a separate building to repackage donated food. In an interview with Roberto Santamaria, director of the Nantucket Health Department, we found that it is possible for multiple organizations to obtain licensing for the use of the same vacant commercial kitchen. Commercial kitchens can be defined as kitchens in public places such as hospitals, schools, churches, and other social organizations. For the purpose of this project, we expanded the definition to include restaurants and inns during their off seasons. Commercial kitchens are shown in Figure 22 in red tacks, the majority of which are located in the downtown Nantucket area with a few scattered in the Surfside and Madaket areas. We chose to separate the rest of the commercial kitchens from restaurants and inns to help distinguish between locations. There currently is not a program in Nantucket to use commercial kitchens in off-times (either at night or during the end of a season). From survey results, restaurants are mostly not interested in having the Nantucket Food Pantry use their kitchens during the off seasons.

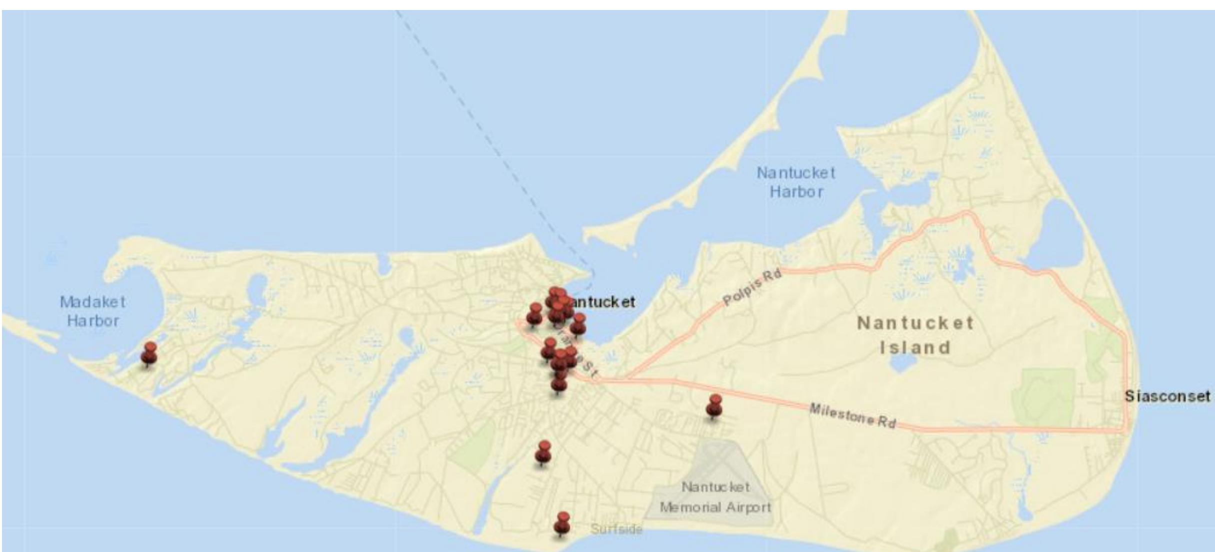

Figure 22: Commercial Kitchens on Nantucket.

- Waste

Waste on Nantucket all currently goes to one location. The Nantucket Department of Public Works operates a landfill on the Madaket side of the island. Figure 23 depicts this location. This is also a registered composting location for the state of Massachusetts. There is currently a program with Sustainable Nantucket to increase the presence of composting in schools, restaurants, and other food locations on the island. The restaurant survey we conducted suggests that there is interest in composting, with some restaurants already currently composting. Many restaurants cited reasons such as smell or lack of space as main deterrents from composting on their own. Don Kolp, the manager at the Brotherhood of Thieves restaurant on island, was interviewed about composting. He stated that their main concern is they do not want the smell to bother their customers. However, Mr. Kolp would be interested if there was a more convenient way to compost off site. He was intrigued at the idea of Sustainable Nantucket and Food Rescue Nantucket working with the high school to set up a composting program to collect from restaurants.

On the other hand, we interviewed Peter McEachern from the Nantucket Yacht Club about how they compost food waste. He described their composting process as: all of the waste goes into a grinder, except for oyster shells and bones; once the waste has been ground up to oatmeal consistency, the Somat machine is used; paddles extract water, dehydrating the waste. That water can then be used to water the grass, and the remaining mass is sent to the landfill where it can now easily dissolve into the soil and help breakdown other landfill materials.

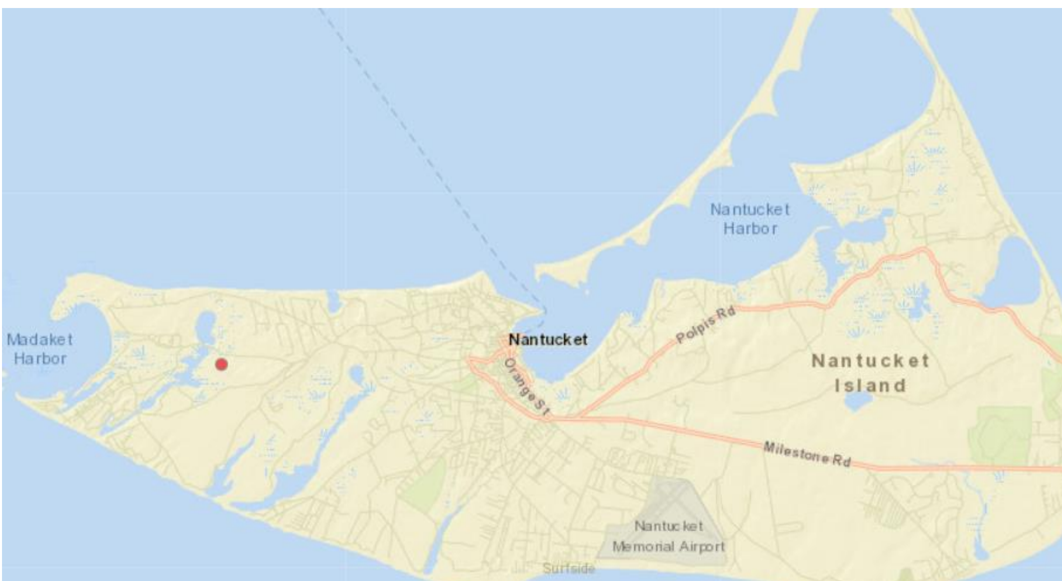

Figure 23: Waste Facilities on Nantucket.

➢ Education

A vital part of Nantucket's food network is food education. Being an island, the community in uniquely aware of its environmental impact. Figure 24 shows food-focused organizations on the island: Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket.

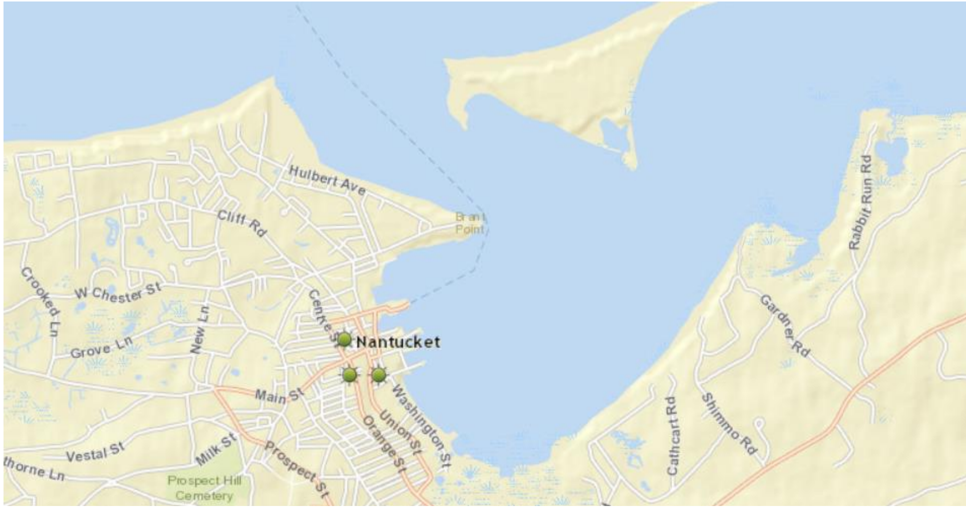

Figure 24: Food-Focused Organizations on Nantucket.

There are opportunities to enhance these organizations' programs. There are several programs that are currently in place to help promote sustainable practices such as *Share Your Harvest*, a program that encourages local farmers and gardeners to share their uneaten food they produced, and the Sustainable Nantucket's Community Farm Institute (CFI), a pilot program that teaches community members who are new to farming how to grow and maintain a farm or garden by using sustainable practices. In fact, only 8 of the 41 producers that we have mapped out attend Sustainable Nantucket's Farmers and Artisans Market (Figure 25).

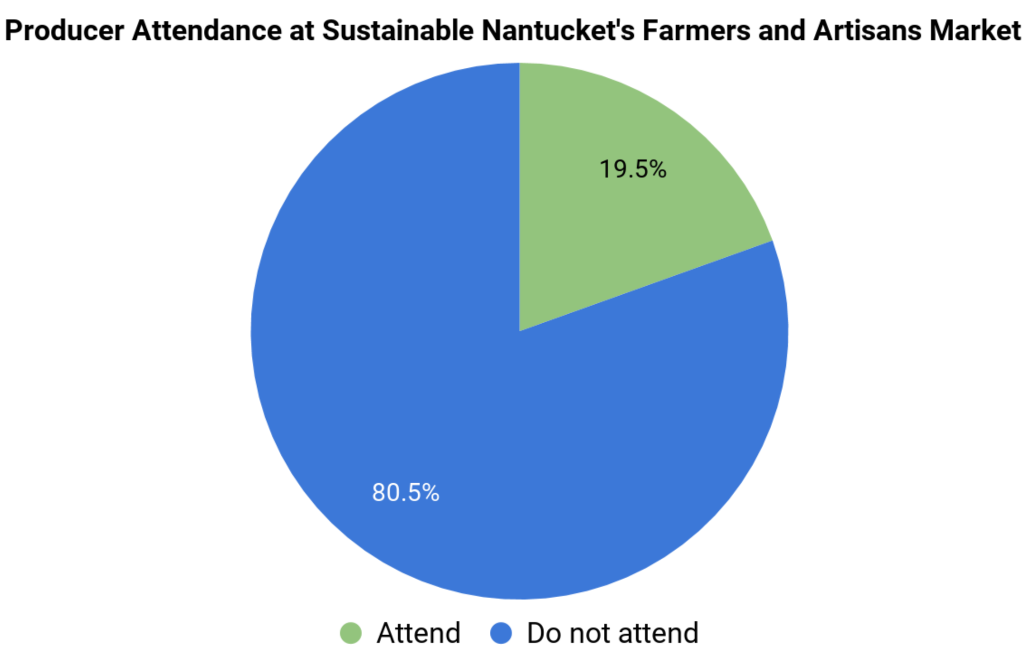

Figure 25: Producer Attendance at Sustainable Nantucket's Farmers and Artisans Market.

Map and Database Content and Usage

A food asset map can be expanded past the primary purpose of identifying areas where food loss occurs, in order to include future endeavors to expand and improve the food system cycle. To create a more comprehensive database of information, we include the following data layers on the food asset map:

- Producers (farms, apiaries, & florists)
- Farms
- Aquaculture
- Distributors
- Storage (dry, freezer, & refrigeration facilities)
- Restaurants
- Lodging (Inns & Hotels)
- Caterers
- Commercial Kitchens
- Waste facilities
- Food-focused organizations

These are the individual data layers because they are the key elements of the Nantucket food network of interest to the stakeholders. Different sets of data were collected on each category, depending on what would be most useful for those using the map. For example, information available when clicking on a producer is shown below in Figure 26:

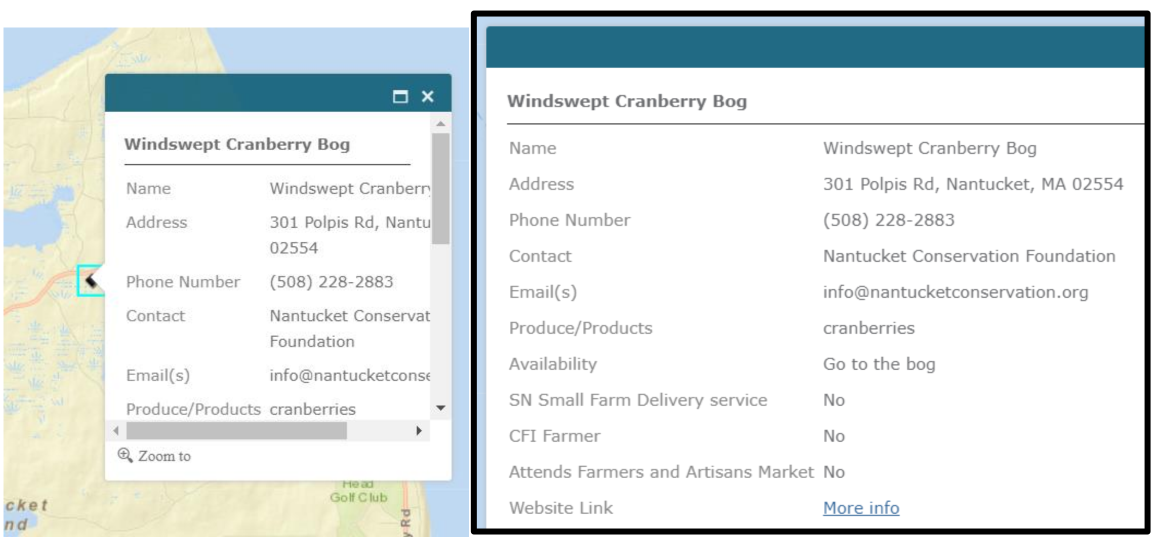

Figure 26: Pop-up Dialogue Box of Producer Information.

To view more material obtained by clicking on a location for the rest of the data layers, see Appendix G.

For the format of our map, we chose ArcGIS Online because we determined it to be the best platform for the map. After evaluating both ArcGIS Online and ArcMap we determined that ArcGIS Online was superior because of its:

- Flexibility and attractive interface
- Ability to integrate with Town GIS data
- Inexpensive licensing for the Nantucket High School
- User friendliness making it easy for high schoolers to continue updating

On the map, the information obtained by clicking on a certain location varies based on the type of location. The update process involves changing our Google Sheets database directly. After updating the information on Google Sheets, that file will need to be converted to a CSV, and then uploaded into ArcGIS Online.

Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket can use the map to promote community discussions about Nantucket's resources. The data included in the map will allow them to analyze Nantucket's food network to find areas for production expansion, along with educating organizations about the assets on the island. Contact information provided to the Nantucket Food Pantry and Food Rescue Nantucket will allow them to form more connections with restaurants and other potential food donors. The map was placed on Sustainable Nantucket's and Nantucket Food Pantry's websites to act as an information hosts, so it can be initially updated in one central location.

Conclusions & Recommendations

In this chapter we detail conclusions and recommendations for Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket based on the food asset map and database as well as interviews with stakeholders and restaurant survey. These conclusions and recommendations are intended to aid in the next steps of the Nantucket Food System Assessment, which will further assess the food production, consumption, waste and recovery, food education, food storage, food technology, and food security assets and needs of Nantucket. The food asset map created for this project is the first database that synthesized this information about the Nantucket food system. It provides the community with a resource intended to spark conversation and change to improve the food network on the island.

The following sections present recommendations about production expansion, future developments, improving food-focused programs, communication, and map promotion.

Production Expansion

There are open areas for aquaculture and agriculture on the island that can be utilized in the food system cycle. Below are recommendations on repurposing ocean plots and open lands for productive use.

- Aquaculture

We encourage the use of the open plots of aquaculture reserved by the Natural Resources Department available for use in Polpis Harbor. Jeff Carlson, Coordinator of the Nantucket Natural Resources Department, explained that this area is ready for use in the future. There are different approaches available for using this land. First, it could be advertised by Sustainable Nantucket and the Natural Resources Department to other growers with leases elsewhere in Nantucket, to inform them of new places they could expand their work. This would allow these areas that are already reserved for aquaculture to be put to good use. On the other hand, these plots could be used for educational purposes. A program could be set up by the Natural Resources Department to educate new growers who are interested in learning about aquaculture and would like to practice it. Similar to Sustainable Nantucket's Community Farm Institute (CFI) where each new farmer has a designated area of farmland, the open plots in Polpis Harbor could be sectioned off for each new grower. Either options for the use of these open plots would help with the expansion of aquaculture in Nantucket, thus increasing the amount of food produced on island.

- Agriculture

To expand the agricultural land on Nantucket, we recommend further research be done to cover all areas of the island. If experts could explore these options, the land could be turned into farmland, orchards, grazing areas, and more, based on their historical usage. This is a long-term idea, potentially something that Sustainable Nantucket could look into in a few years when they would like to take on a new endeavor.

Future Developments

A stronger, more developed food network on Nantucket can lead to a more effective system in the community. The Nantucket Food Pantry lacks resources to benefit and reach a wide client-base. Additionally, the food asset community could benefit from having a larger and better defined local Food Hub. In this section, we present recommendations for the Nantucket Food Pantry to partner with a commercial kitchen and for the Sustainable Nantucket's Community Farm Institute to establish a more defined local Food Hub for the Nantucket local food community.

- Food Pantry

The Nantucket Food Pantry can work with the Nantucket Health Department and interested commercial kitchens in the future to arrange licensing to use vacant local commercial kitchens. Obtaining a commercial kitchen license would greatly expand the Nantucket Food Pantry capabilities by allowing them a space to repackage foods that are donated to them for redistribution to their clients. This would expand their current donation capabilities and they would be able to receive more food from organizations; such as restaurants closing down for the season who may be willing to donate excess food.

In order to gain a better understanding of potential commercial kitchens' availabilities, we recommend a schedule be created of their opened/closed dates. This would allow the Food Pantry to analyze their options, and coordinate with any interested commercial kitchens.

Another component to the food cycle are the consumers that buy food online and have it shipped to their houses. To reach this portion of the public, online food purchasers could be made aware of donating capabilities. Tagged along to a consumer resident survey about how they use their food, residents could be invited when purchasing their online food to make a donation. The donation could then be shipped directly to the Food Pantry, providing an easy way to send food without the residents having to drop it off themselves.

- Local Food Hub

We recommend that Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket work together in establishing a local Food Hub. A Food Hub is a place where distribution, production, and exchange of food can happen. The first step is to get the three organizations together for a discussion. The various entities can then explore what a Food Hub in Nantucket would be like. Sustainable Nantucket had a local Food Hub the past few years which gathered small producers on the island together for restaurants to pick up produce. This provides a starting point to expand upon. A Food Hub would help alleviate food storage issues as well as institute a location for increased face-to-face communication for producers, consumers, and chefs. A place for this local Food Hub could be developed in the next 3-5 years with Sustainable Nantucket's CFI. Representatives from Sustainable Nantucket envision the CFI becoming a larger, more market-focused asset in the food community. Below in Figure 27, is a flow diagram of how Nantucket's food system currently operates. Following that is Figure 28, which adds a local Food Hub to simplify and centralize the system, bringing the community together.

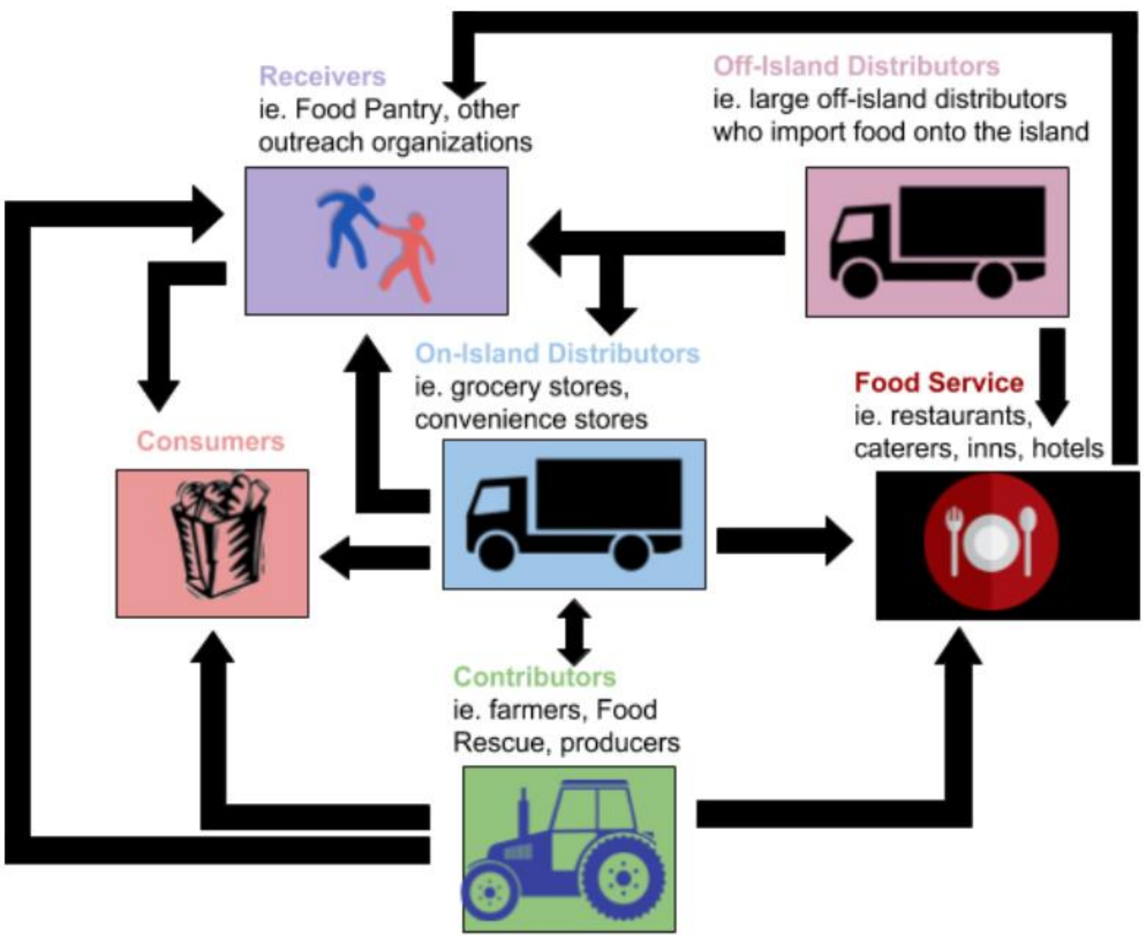

Figure 27: Nantucket's Current Food System Diagram.

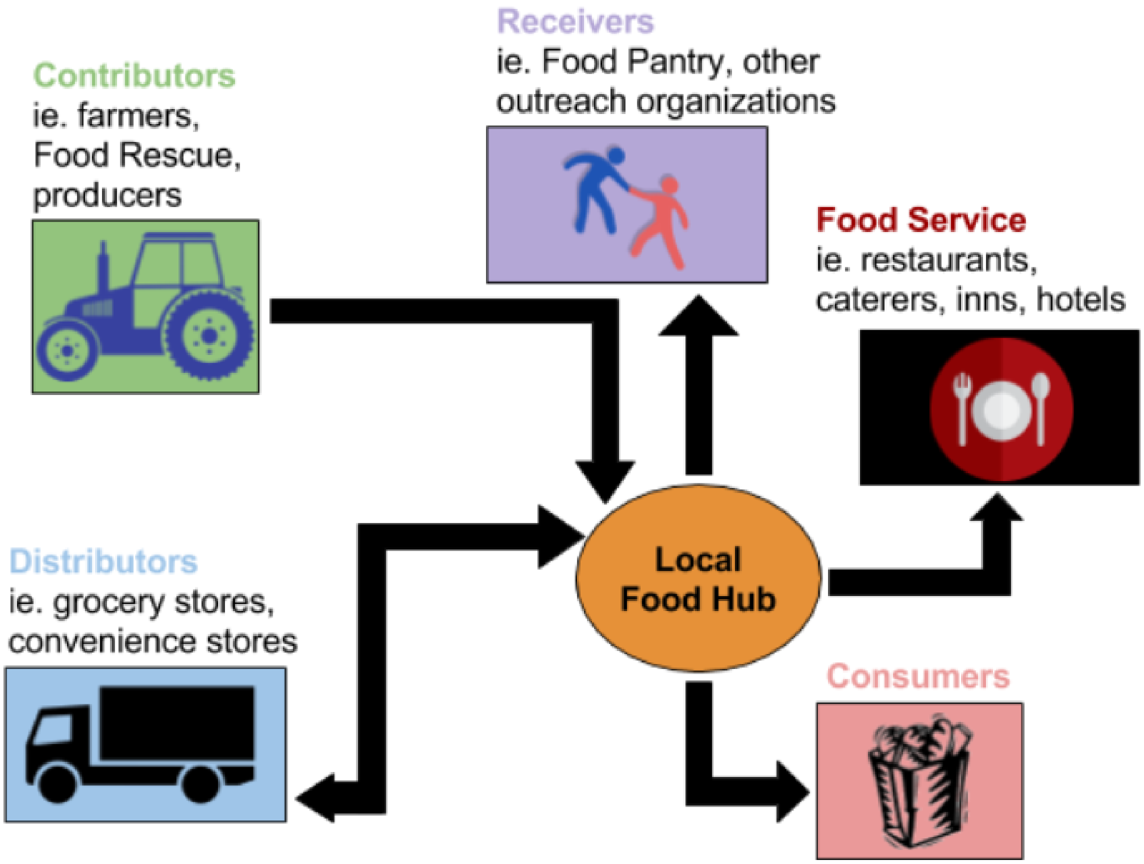

Figure 28: Local Food Hub Flow Diagram.

Expanding Food-Focused Programs

Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket foster important relationships with the community. Programming is a valuable way to strengthen these relationships. It can educate the community on the organizations and promote future communication.

Using the list of producers from the map and database can allow organizations that aim to collect food in the community to expand their collection programs. The current food collection programs are limited due to lack of knowledge of some food producers on the island. Below are our recommendations related to improving the popularity and effectiveness of a few of these organizations' programs.

➢ Nantucket Food Pantry - *Share Your Harvest*

The Nantucket Food Pantry can better promote the *Share Your Harvest* program to attract new donors and inspire individuals to create additional backyard gardens. It can also work with Food Rescue Nantucket to organize pick-ups and gleaning from residences to the Food Pantry. The *Share Your Harvest* program currently relies on people to donate excess food and does not include a gleaning initiative. Because gleaning is a particular area of focus for Food Rescue Nantucket it could be beneficial for the two to partner together to increase donations to the food pantry.

- Food Rescue Nantucket – Gleaning

Food Rescue Nantucket only gleans at two farms, Moors End Farm and Bartlett's Farm, since it is a new organization. Although contact has been made with other farms on island, we would recommend reaching out to them again at the beginning of next season. The map could act as a database of potential new areas to glean. With examples to give of the services provided at the two farms in the prior year, other farms may be more open to the idea of working with Food Rescue Nantucket in future years.

- Food Rescue Nantucket - Drop-off Boxes

There are currently three drop-off box locations to collect donations of unopened, non-perishable food items in residential areas that often include rental properties. These box locations could be expanded to make it more convenient to more residents (in a closer proximity to them). This would make it easier for residents to contribute, which may increase the amount of donations Food Rescue Nantucket receives for its recipients.

- Nantucket Food Pantry - Creation of *Food for Fines* Program

In order to better enhance the presence of the Food Pantry on island and increase the amount of food the Food Pantry obtains, we recommend the implementation of a *Food for Fines* program at the Nantucket Atheneum. This program would allow library members to drop off cans of food in exchange for a reduction of any overdue fines. In turn, the Nantucket Atheneum does not have any withstanding fines with members, and the Food Pantry is increasing their food donations they receive. Many libraries including the WPI library already implement programs such as these. They have a positive impact on the community as they increase awareness and involvement in local food pantries.

Nantucket High School Program

In order to ensure the food asset map is most effective, we recommend Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket continue working with the Nantucket High School to update and add missing information to the food asset map. This will involve working with the Nantucket High School IT department to get the free K-12 ESRI ARC package. Once the software is installed, more map features can also be added and experimented with to improve the user-friendliness of the program, since the base food asset map was not created with a full ArcGIS Online account. The Nantucket High School students can update the map annually using the Google Sheets database, access to the online mapping tool, and the user manual. Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket can continue working with the Nantucket High School to update the existing data, fill in missing information (i.e. all distributors used by all restaurants on the island), and add any desired improvements to the map.

Communication

After multiple meetings with Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket, individually with each organization and all together, we concluded that better communication between the organizations and others involved in the food network on island would be especially useful. It became evident from these meetings that the three organizations are not always aware of all aspects of each other's programs due to the lack of platforms connecting them. With an increase in communication, as well as the database from the map acting as a central location for their data, they would all experience more promotion of their organizations and programs. In that way, involvement between the organizations could also increase.

The development and usage of the food asset map can help to bring Sustainable Nantucket, the Nantucket Food Pantry, and Food Rescue Nantucket closer together. It holds pertinent information for each organization, and gives them common ground to build from. Using the map and adjacent data, they may be able to discuss programs, strategies, and collaborations.

To further improve cross-promotion of each organization and increase involvement in each other's programs and events, we also recommend that Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket look into different communication platforms (e.g., the program Slack). The three organizations, while all having individual areas of interest, have many overlapping goals such as reducing food waste and promoting more sustainable practices that can help to improve food security on the island. A platform that could facilitate more communication between organizations would allow them all to stay organized and involved.

Map Promotion

Additionally, we recommend that Sustainable Nantucket, Nantucket Food Pantry, and Food Rescue Nantucket promote the food asset map and ideas about the food system on the island to better engage the community. We encourage this be done through the use of different forms of media in order to reach a larger audience. A few guidelines to best promote the food asset map, programs, events and other sustainable topics by the three organizations may include:

- Dedicate a page on the Sustainable Nantucket's website to the food asset map to explain the organizations involved and the map's role in the Comprehensive Food System Assessment.
- Place the food asset map and information on multiple platforms such as in local newspapers, on Facebook, Instagram, and Twitter, to reach as many people as possible.
- Post about events on media before they happen, rather than after, in order to improve attendance of these events.
- Post fun, engaging, and eye-catching photos with some details in the description to be informative and grab the audience's attention.
- Engage with others on social media. If someone tags your organization in a post like it and potentially comment on it when appropriate. Also, depending on the post and how applicable it is, you could repost the picture as long as you indicate it is a repost.

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APPENDICES

Appendix A: Farming on Nantucket

In addition to Bartlett's Farm, other farms on the island include: Moors End Farm, Far Away Farms, Boatyard Farm, Pumpkin Pond Farm, Cisco Sanctuary, Nantucket Blooms, Nantucket Organics, Berry Patch Farm, and Sustainable Nantucket's Community Farm Institute Growers (Lazy Man Gardens, ACK Sweetwater Farm, Fields of Ambrosia, and Washashore Farm). The sizes of some of these farms can be seen in Table 3.

Farm	Size (acres)
Bartlett's Farm	197, 97 in production
Moors End Farm	18, 13 in production
Pumpkin Pond Farm	10, 1.25 in production
Sustainable Nantucket's Community Farm Institute Growers	8.5, 1.375 in production
Boatyard Farm	1.25
Berry Patch Farm	0.3

Table 3: Nantucket Farms by Size.

There are also other small-scale, specialist growers on the island. Sustainable Nantucket started an initiative in 2011 with the Pilot Grazing Project. They partnered with the Nantucket Islands Land Bank and Faraway Farms to use low-impact rotational grazing, and aim to "eventually create a network of grazed and cultivated land all over the island" (Sustainable Nantucket, 2011).

Appendix B: Cranberry Bogs on Nantucket

Cranberries have been an important asset on Nantucket since the days of the natives and early settlers, and the Nantucket Cranberry Company was founded in 1916 (Jenness, 2015). With the expansion of the whaling industry, cranberries became a vital resource. By 1683 settlers were making juice from cranberries, by 1820 they were making shipments to Europe, and by 1850 they were being used by whalers to prevent scurvy at sea (Our BERRIES, 2003-2016). As the whaling industry collapsed cranberry farming became one of Nantucket's surviving industries. After a downturn in the cranberry market in 1999, the early 2000s saw a resurgence of the cranberry production on the island.

Appendix C: Aquaculture on Nantucket

Oyster farmers use long rack systems with rebar frames to support plastic bags, which hold millions of oysters in different developmental stages (Burch, 1994). There are 8 oyster farms in Nantucket, with seven still being the most active. These include: 5th Bend Oysters, Bass Point Oysters, Great Harbor Oysters, Great Point Oysters, Grey Lady Oysters, Pocomo Meadow Oysters, and Retsyo Oysters. While it is a productive food resource, oysters are also beneficial for the environment. Locations for some of the oyster farms and the Brant Point Hatchery are pictured below in Figure 29. Oysters filter about 15 gallons of water per day, so these aquaculture areas provide "ecosystem services that aid in moderating impacts such as nutrient eutrophication in our coastal waters" (Nantucket Shellfish Management Plan Committee, 2012).

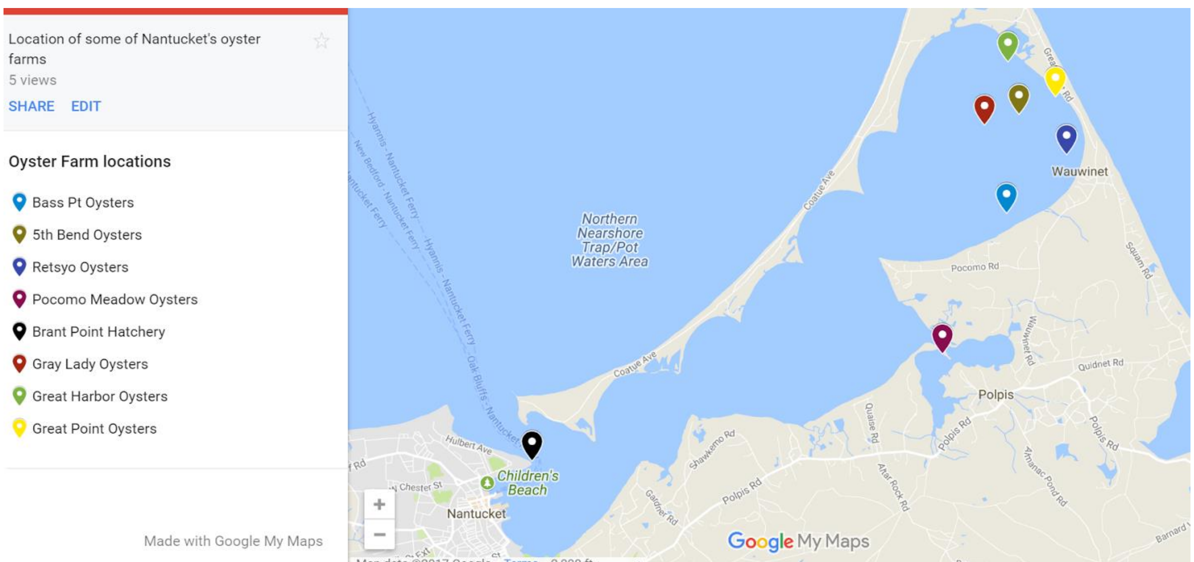


Figure 29: Locations of Oyster Farms and Brant Point Hatchery.

Appendix D: Interview Preamble

We are a group of students from Worcester Polytechnic Institute (WPI), working with Sustainable Nantucket, the Nantucket Food Pantry, and Food Rescue Nantucket. Our goal is to learn about food asset mapping and analysis, which will assist us in efforts to evaluate the food systems cycle in Nantucket. This conversation should only take about half an hour. Can we quote you in our final report, or would you prefer your comments to remain anonymous? We will give you an opportunity to review any quotations that we will use prior to final publication. If you have any concerns about the research, contact us at ack17sn@wpi.edu. You may also contact our WPI project advisors, Professors Dominic Golding (golding@wpi.edu) and Richard Vaz (vaz@wpi.edu).

Appendix E: Surveys

We are a group of students from Worcester Polytechnic Institute (WPI) working with Sustainable Nantucket, the Nantucket Food Pantry, and Food Rescue Nantucket to create a food asset map of Nantucket. This map will serve as a resource to understand and create connections between producers, distributors, and purveyors of food on the island.

The purpose of this survey is to add more information to the map and associated databases regarding Nantucket restaurants. The information you provide will be shared with Sustainable Nantucket, the Nantucket Food Pantry, and Food Rescue Nantucket. We will give you the opportunity to review the map and databases before they are published online so you can determine what if any information you may wish to remain confidential.

If you have any questions about this research project, you may contact us at ack17sn@wpi.edu. Thank you for your participation.

Restaurant Survey Questions:

- What is the name of your restaurant?
  - Fill in the Blank
- When is your restaurant open?
  - Year round
  - Seasonally, open during which months and include other additional times (examples: Thanksgiving, Stroll, etc.): fill in blank
- Seasonal: Would you be willing to have your kitchen or freezer/refrigerator be used after you are closed for the season? This would be used by the Nantucket Food Pantry.
  - Yes
  - No
  - Maybe, under these circumstances: (fill in blank)
- Do you source any of your food from on-island producers?
  - Yes
  - No
- If yes: from which of these local producers do you regularly source foodstuffs (Click all that apply)
  - Ace Sushi
  - ACK Sweet Water Farm
  - Ambrosia Chocolates & Spices
  - Bartlett's Farm
  - Bass Point Oysters
  - Bee Happy Honey Co.
  - Berry Patch Farm
  - Boatyard Farm
  - Captain Bill Blount and the Ruthie B. Community Supported Fishery

- Cisco Brewery
- Fields of Ambrosia
- The Flower Farm
- Gliddens Island Seafood
- Grey Lady Oysters
- Island Bee Girls
- Island Lumber
- Lazy Man Gardens
- Moors End Farm
- Nantucket Bake Shop
- Nantucket Bottled Water
- Nantucket Coffee Roasters
- Nantucket Fresh Catch
- Nantucket Jams
- Nantucket Organic
- Nantucket Seafoods
- Nantucket Toffee
- Nantucket Wildflower Farm
- Nantucket Blooms
- Pocomo Meadow Oysters
- Retsyo Oysters
- Salty Balls Seafood
- Sayles Seafood
- Something Natural
- Sunny's Honey
- Washashore Farm
- Wicked Island Bakery
- 5th Bend Oysters
- Other (fill in blank)

- If yes: Which of the following items do you get on-island (check all that apply)?
  - Vegetables
  - Shellfish
  - Fish
  - Fruit
  - Dairy
  - Beverages
  - Meat

Which of the following major off-island food sources do you use regularly?

- D'Artagnan Foods
- Dole & Bailey
- Sysco
- Seacrest Foods
- Shapiro Produce
- Sid Wainer & Son
- Sun Island Delivery
- US Foods
- Other (fill in blank)

- Would you be willing to donate excess food to the Nantucket Food Pantry? Volunteers from Food Rescue Nantucket could come and pick up the food from your restaurant.
  - Very unwilling
  - Unwilling
  - Neutral
  - Willing
  - Very willing

    - I already donate some of my excess food to the Nantucket Food Pantry.
- Do you sell takeout foods at your restaurant?
    - Yes
    - No
- If yes, is the food prepackaged with ingredients labeled? The Nantucket Food Pantry can only use excess takeout food if it is individually wrapped and labeled.
    - Yes
    - No
- Does your restaurant offer catering services?
    - Yes
    - No
    - Comments (fill in blank)
- Does your restaurant participate in any composting programs?
    - Yes
    - No
    - Not currently, but interested.
    - Comments (fill in blank)

Inn Survey Questions

- What is the name of your inn?
    - Fill in the Blank
- When is your inn open?
    - Year round
    - Seasonally, open during which months and include other additional times (examples: Thanksgiving, Stroll, etc): fill in blank
- Seasonal: Would you be willing to have your kitchen or freezer/refrigerator be used after you are closed for the season? This would be used by the Nantucket Food Pantry.
    - Yes
    - No
    - Maybe, under these circumstances: (fill in blank)
- Do you source any of your food from on-island producers?
    - Yes
    - No
- If yes: from which of these local producers do you regularly source foodstuffs (Click all that apply)
    - Ace Sushi
    - ACK Sweet Water Farm
    - Ambrosia Chocolates & Spices
    - Bartlett's Farm

- Bass Point Oysters
- Bee Happy Honey Co.
- Berry Patch Farm
- Boatyard Farm
- Captain Bill Blount and the Ruthie B. Community Supported Fishery
- Cisco Brewery
- Fields of Ambrosia
- The Flower Farm
- Gliddens Island Seafood
- Grey Lady Oysters
- Island Bee Girls
- Island Lumber
- Lazy Man Gardens
- Moors End Farm
- Nantucket Bake Shop
- Nantucket Bottled Water
- Nantucket Coffee Roasters
- Nantucket Fresh Catch
- Nantucket Jams
- Nantucket Organic
- Nantucket Seafoods
- Nantucket Toffee
- Nantucket Wildflower Farm
- Nantucket Blooms
- Pocomo Meadow Oysters
- Retsyo Oysters
- Salty Balls Seafood
- Sayles Seafood
- Something Natural
- Sunny's Honey
- Washashore Farm
- Wicked Island Bakery
- 5th Bend Oysters
- Other (fill in blank)

- If yes: Which of the following items do you get on-island (check all that apply)?
    - Vegetables
    - Shellfish
    - Fish
    - Fruit
    - Dairy
    - Beverages
    - Meat
- Which of the following major off-island food sources do you use regularly?
    - D'Artagnan Foods
    - Dole & Bailey
    - Sysco
    - Seacrest Foods
    - Shapiro Produce
    - Sid Wainer & Son
    - Sun Island Delivery
    - US Foods

    - Other (fill in blank)
- Would you be willing to donate excess food to the Nantucket Food Pantry? Volunteers from Food Rescue Nantucket could come and pick up the food from your inn.
    - Very unwilling
    - Unwilling
    - Neutral
    - Willing
    - Very willing
    - I already donate some of my excess food to the Nantucket Food Pantry.
- Does your inn offer catering services?
    - Yes
    - No
    - Comments (fill in blank)
- Does your inn participate in any composting programs?
    - Yes
    - No
    - Not currently, but interested.
    - Comments (fill in blank)

Appendix F: User Manual

1. Overview

Sustainable agriculture works to meet the food needs of today without compromising the food security of tomorrow. Communities are now promoting more locally sourced food through farmers markets, supplying fresh produce to food pantries and local schools, as well as a growing resurgence of practices such as gleaning that reduce food waste.

Sustainable Nantucket, the Nantucket Food Pantry and Food Rescue Nantucket are three organizations promoting sustainable food activities on the island. Sustainable Nantucket promotes sustainable agriculture to protect the environment while increasing the island's self-reliance. The Nantucket Food Pantry provides vital support to many families and individuals struggling to make ends meet, and Food Rescue Nantucket works to stop food from ending up in landfills. As a developed island community, Nantucket's opportunity to grow agricultural resources is limited. Even so, this local food system is not being used to its full potential.

To construct a more sustainable community, food asset mapping is a useful visualization technique. This method marks out local areas that contribute to the community food cycle and helps gain an understanding of what resources a community has. The existing food network on Nantucket can be analyzed and enhanced. The creation of a food asset map is part of the larger endeavor of a comprehensive food assessment. This can help to highlight spaces not being used to their full potential or areas that show possibilities for future agricultural expansion; being beneficial for local sustainably focused organizations.

Taking ownership of this map will allow the map to be maintained and updated. This is imperative in order to continue the collaboration between the sustainable organizations on Nantucket and to enhance the local food system.

1.1 Platform Overview

ArcGIS Online is an online GIS system that allows one to create, share, and analyze geographical data. ArcGIS Online supports features such as: the ability to create an online map, import data layers onto it, and make the map accessible to the community. The publishing features are versatile, including the option of creating a web application from the map.

1.2 Important Terminology

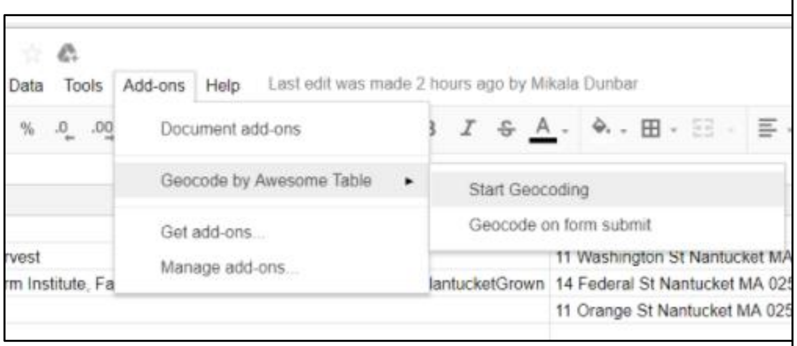
GIS	Geographic Information Systems
Food Asset	Location where a community grows, prepares, shares, buys, receives, or learns about food
Point Data	Depicts discrete locations (longitude, latitude)
Parcel Data	Depicts a collection of pieces of land
Data Layer	Set of related locations

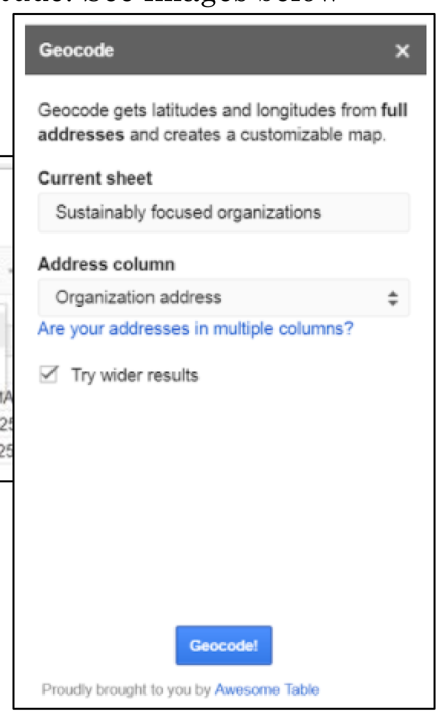
1.3 Items to Update on the Food Asset Map

- Google Sheets
- Parcel Data
- ArcGIS Online Certification

2. Updating Google Sheets Data

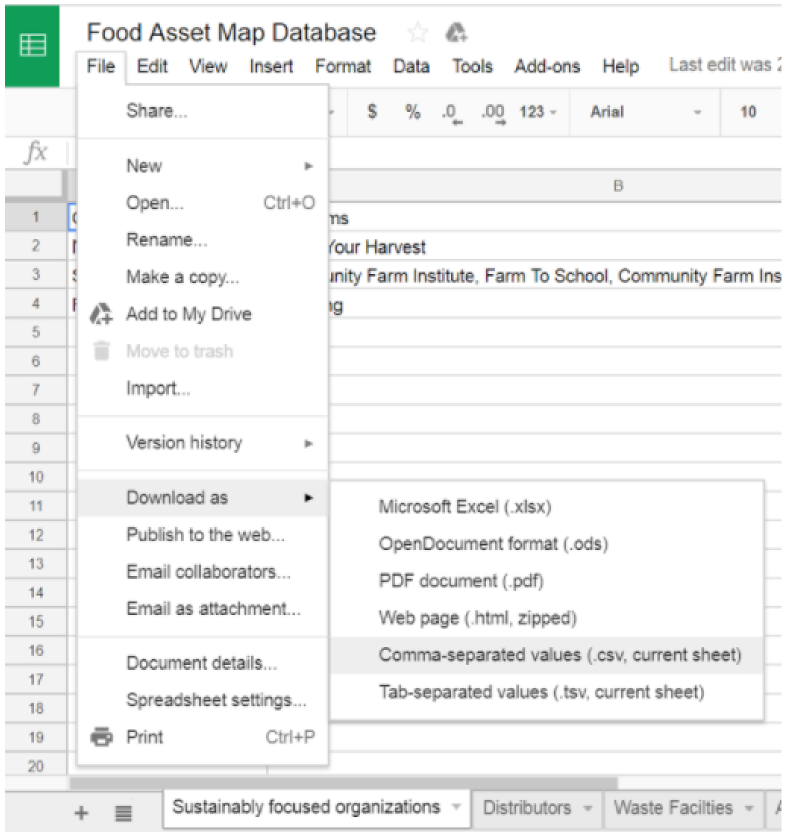
1. Access the Google Sheets spreadsheet titled "Food Asset Map Database" on Google Drive.
2. The Food Asset Map Database is organized in different sheets, based on data layer of the map. Each data layer contains different assets. Within each sheet, you can update by adding new assets and deleting those that are no longer active.
3. Click "Add-ons" on the top help bar.
4. Under "Add-ons" click "Geocode by Awesome Table" => "Start Geocoding".
   When the pop up appears on the right, ensure that Address column is the column with the addresses, then hit Geocode. This runs the add-on to convert new addresses to latitude and longitude. See images below for further detail.





2.1 Preparing Google Sheets to upload to ArcGIS Online

1. Download each sheet directly from Google Sheets as a CSV file by clicking "File" then "Download as" and "Comma-separated value (.csv, current sheet)."
   The step is illustrated in the image below.



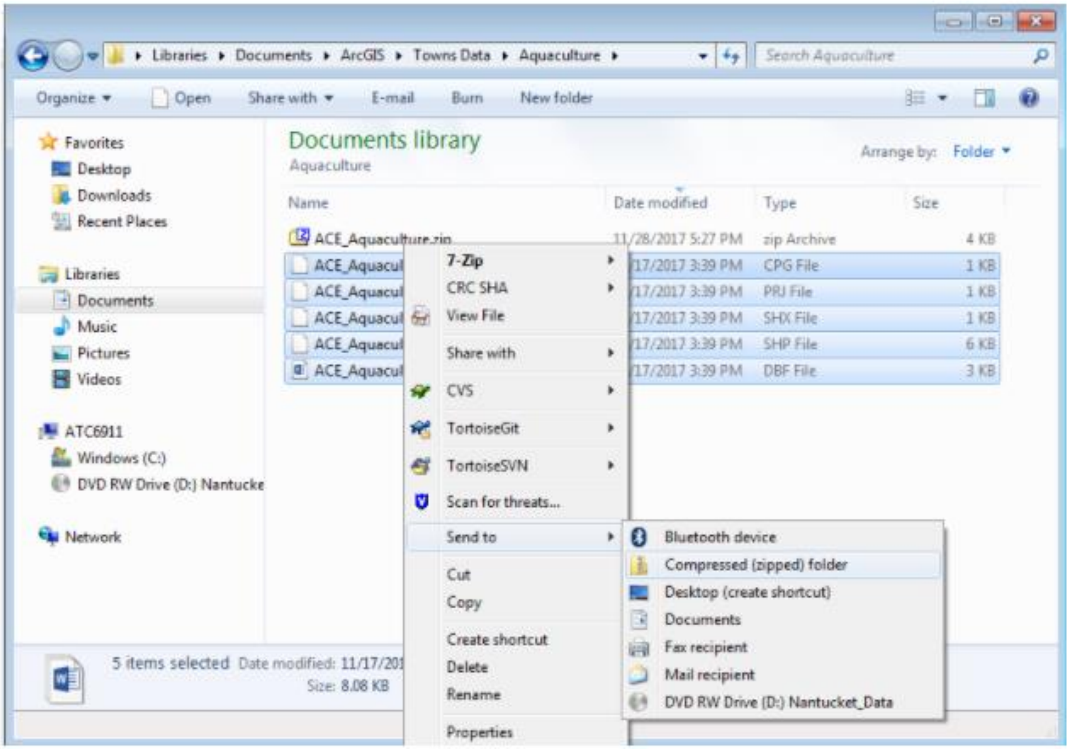
2. Follow directions below at Section 4 Updating ArcGIS Online

3. Preparing the Parcel Data to Upload to ArcGIS Online

Some files of parcel data can be accessed through the Nantucket Town gIS and then uploaded to the online food asset map.

3.1 How to upload parcel data to ArcGIS Online

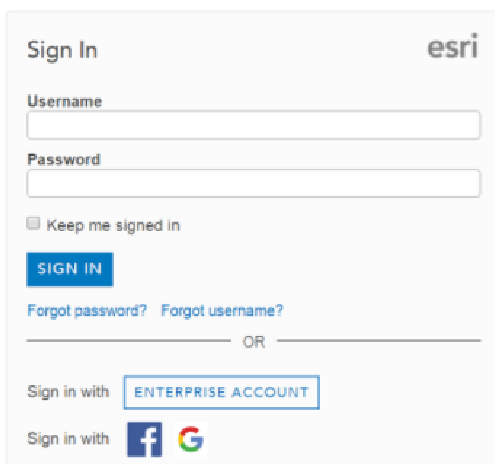
1. Contact the current Nantucket Town GIS coordinator to get the most updated versions of files such as Aquaculture or land usage.
2. After acquiring the data, highlight the files needed, right click and click “Send to” then “Compressed (zipped) folder.”
   It is important to note: there are limitations to how much data can upload at once. Shape files or CSV files can only upload 1000 features or 250 addresses at a time.



3. Once the data is converted to a zip file, it can be uploaded to ArcGIS Online following the instructions below in Section 4 Updating ArcGIS Online.

4. Updating ArcGIS Online

1. Navigate to the ArcGIS Online sign in through your web browser and enter the proper credentials.



2. To access the already existing map, go to Content and "Nantucket Food Asset Map"
3. Click "Open the map with map viewer"

4.1 Add a layer

1. Click “+Add”
2. Click “Add Layer from File”
3. Choose the CSV file that was downloaded from Google Sheets, or the zip file created from the parcel data.

4.2 Delete a layer

1. Find the data layer you wish to delete in the Details tab, under Contents. This is a list of the data layers.
2. Click on the data layer, then on the three dots for more options.
3. In More Options, select “Remove”

4.3 Save your work

1. Click “Save” at the top of the window.
   This saves your changes on the account and updates the link to the map.

5. Special Cases

5.1 Oyster Farms

- Most oyster farms are depicted in relative areas of the harbor. They do not have exact locations to enter in the database. **Using Google Maps, approximate latitudes and longitudes were found and inputted into the Oyster Farms Google Sheets tab.**
- On Google Sheets, there is both a tab for Oyster Farms and Producers. The Oyster Farms are included in the Producers tab. The Oyster Farms tab is used as a working space, not to be uploaded, while the Producers tab does get uploaded to the map.
- To upload the Oyster Farms in their correct locations on the Producers data layer, follow these steps starting in the Producers data tab:
  a) Geocode the data (described starting in Section 2, step 3). This adds latitudes and longitudes for all data points here, putting in random latitudes and longitudes for the oyster farms.
  b) Go to the Oyster Farms tab, and manually copy these latitudes and longitudes to the Producers tab in the corresponding rows.
  c) This data layer can now be downloaded as a CSV file (Section 2.1) and uploaded to the map (Section 4).

5.2 Private Producers

- Information in this data layer is not publicly available. Therefore, it must be kept private. This also means that we do not have specific addresses for these locations, if anything we were given areas of Nantucket or just a road name.

- To upload more points on this layer, you must manually input each point by following these steps:
    a) Click “+Add”
    b) Click “Add Map Notes”
    c) Click “Create” and then select the shape of the point you wish
    d) Click on the point when it appears on map, and input all necessary data
    e) Click on the point on the map and drag it to move its location
    f) Click “Close” when satisfied with the point’s location
    g) Click “Save” at the top of the window

6. ArcGIS Online Certification

To learn about and obtain this free subscription, follow these steps:

1. Visit esri.com
2. Click the “Industries” tab at the top of the page.
3. Click “Education”
4. Go to the “Schools” tab
5. Click “Schools Software Bundle”
6. Fill out the form on the page to request a Free ArcGIS for Schools Bundle.

Appendix G: Information given within each layer

- ***Producers:** name, address, latitude, longitude, phone number, contact name, email address, website link, produce, availability, and more sponsor tailored information like: whether or not they are involved with SN Small Farm Delivery service, Community Farm Institute, or if they attend SN's Farmers and Artisans Market
- **Farms:** name, address, latitude, longitude, phone number, contact name, email address, website link, produce, availability, and more sponsor tailored information like: whether or not they are involved with SN Small Farm Delivery service, Community Farm Institute, or if they attend SN's Farmers and Artisans Market
- **Areas of aquaculture:** Owner, size (acres), address, latitude, longitude
- **Distributors:** Name of business, address, latitude, longitude, phone number, email, website, distribution or grocery.
- **Storage:** Organization, address, latitude, longitude, freezer (y/n), refrigeration (y/n), description.
- ***Restaurants:** Restaurant name, address, latitude, longitude, service style, phone number or email, NantucketGrown™ certification level, Takeout (Y/N), individual packaged takeout (Y/N), active season, website.
- **Lodging:** Inn/Hotel name, address, latitude, longitude, service style, phone number, season, website.
- **Caterers:** Caterer name, address, latitude, longitude, phone number, website, email.
- **Commercial kitchens:** Organization, address, latitude, longitude, phone number, website, email.
- ****Food Rescue recipients:** Organization, address, latitude, longitude, phone number, website link.
- **Waste Facilities:** Name, address, latitude, longitude, type, phone, email.
- **Food-focused organizations:** Organization name, programs, organization address, latitude, longitude, organization description, phone number, email contact.

* Some information is private (not on our public map) ** Entire data layer is private

Appendix H: Link to the Food Asset Map

https://arcg.is/18CyWy

Appendix I: Summative Team Assessment

Our team worked effectively and respectfully together. We created an agenda for every day, meeting, and interview. These agendas were filled with minutes, important deadlines, and plans. We also tracked work contributed throughout the day by each individual in order to ensure equal workloads. We set deadlines for ourselves before mandatory deadlines throughout the seven weeks, allowing for us to accomplish all goals and tasks timely. Open communication allowed for discussion of feelings and other concerns throughout our time. We delegated work equally to members based on everyone's strengths. We also allowed for individuals to work on weaknesses to better improve teamwork and individuals' skillsets.

We have communicated effectively amongst ourselves, advisors, and sponsors. After each meeting, minutes and notes were emailed out to everyone who participated to ensure we were all on the same page. A unique challenge to our project was having three sponsor organizations. This became challenging at times to balance everyone's interests and needs relative to our work. We were able to ensure that all three organizations were continuously content with our work through constant check-ins with them and frequent updates. We also met with them individually and in groups. We kept our advisors up-to-date with any developments or challenges within the project or with our sponsors. For example, cover letters were sent to advisors to update them of relevant topics and project changes when sending them reports. In addition, when we had a change in representatives from one of our sponsor organizations due to an absence, we notified advisors and kept them updated for when the sponsor was able to return.

In future projects, we will remember the challenges and successes that we had. An area that we will look to improve upon in the future is communication within the team to solve conflict as it arises. For example, if someone does not agree with another's opinion they should discuss it in the moment to avoid building unnecessary tensions. We will take into account strategies that worked well too, i.e. vigorous notetaking, organization of files, and open lines of communication with important project stakeholders.

Overall this project was a beneficial experience for learning and building teamwork and technical skills.

APPENDIX C

Public Outreach Efforts

Including: Community Engagement Report
Community Engagement Report Update
Public Meeting Presentation Materials – February 2020
Public Meeting Presentation Materials – July 2020

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REPORT

December 15, 2019

TOWN OF
Nantucket
MASSACHUSETTS

Anaerobic Digester Feasibility Study
Community Engagement Report

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The Town of Nantucket (Town) and Weston & Sampson are conducting a feasibility study to evaluate the potential for developing an organics-to-energy project at the Town-owned Surfside Wastewater Treatment Facility (WWTF) through a grant provided by the Massachusetts Clean Energy Center (MassCEC). The study will provide a determination of the technological feasibility and economic viability of adding one or more anaerobic digesters to the WWTF. If found to be feasible, the addition of anaerobic digestion technology would provide the island with an alternative source of energy, thereby decreasing energy demands and costs, as well as providing volume reduction of source separated and WWTF waste, reducing demand on the island's already limited landfill capacity.

In preparing the feasibility study, it is imperative to evaluate community compatibility by identifying potential impacts to and concerns of the Nantucket community. Therefore, the Town has identified community stakeholders and has developed a plan to engage and solicit feedback from these stakeholders throughout the duration of the study. This Community Engagement Report will outline the planned public outreach activities and stakeholder communication efforts.

1.0 STAKEHOLDER IDENTIFICATION

A project kickoff meeting was held on November 21, 2019 at the Surfside WWTF; representatives from the Sewer Department, Town Administration, Board of Health, Energy Office, Department of Public Works, and Weston & Sampson were in attendance. At this meeting a preliminary group of stakeholders was identified as listed in Table 1 below. As this is a preliminary list, it is anticipated that the list will change over the course of the study.

For several of the stakeholders, a project representative or contact has already been identified and is an active participant in the project. For others, a project representative or contact has not yet been identified. Of these stakeholders, those which are large producers of organic waste will be directly contacted as the technological evaluation of the study progresses beginning in January 2020.

Potential interests have been identified for each stakeholder by the attendees of the kick-off meeting but are likely to change with increased communication and the progression of the study.

Table 1: Preliminary List of Identified Stakeholders

Stakeholder	Project Representative/ Contact	Potential Interest
Nantucket Sewer Department	David Gray, Sewer Director	Operator of digester; Additional changes to WWTF operations, including energy use, solids management, and septage, leachate, and food waste receiving; Opportunity for reduction of FOG in the collection system
Nantucket Town Administration & Select Board	Rachel Day, Assistant Town Manager; Florencia Rullo, Public Outreach Manager	Opportunity for reduced sewer costs through energy production; Concern for impact to proximate neighbors

Table 1: Preliminary List of Identified Stakeholders		
Nantucket Board of Health	Roberto Santamaria, Health Director	Enforcement of Board of Health Requirements; opportunity for better compliance with FOG regulations
Nantucket Energy Office	Lauren Sinatra, Energy Coordinator	Opportunity for new energy source; Reduced energy demand by WWTP; Energy generation returned to grid during peak demand in the summer; Opportunity to promote Town as a leader in clean energy
Department of Public Works /Waste Options Nantucket	Rob McNeil, Public Works Director; Graeme Durovich, Recycling/Solid Waste Coordinator	Concern for impacts to existing composting operation
Surfside WWTP Abutters/ Proximate Neighbors	-	Concern for increased truck traffic, potential visual, auditory, and odor impacts
Greater Nantucket Community/ Residents	-	Opportunity for reduced sewer costs through energy production; Concern for increased truck traffic, potential visual, auditory, and odor impacts
Cisco Brewers	-	Opportunity for organic waste disposal
Stop and Shop	-	Opportunity for organic waste disposal
Nantucket Public School District	-	Opportunity for organic waste disposal
Nantucket Cottage Hospital	-	Opportunity for organic waste disposal
Other Large Generators of Organic Waste	-	Opportunity for organic waste disposal
Food Rescue Nantucket	-	Opportunity to connect community interests in food waste reduction
Massachusetts Department of Environmental Protection	-	Enforcement of permitting and regulatory requirements
MassCEC	Amy Barad, OTE Program Director	Grant source; Oversight and guidance for organics-to-energy program requirements

2.0 STAKEHOLDER COMMUNICATION

2.1 Public Meetings

Several methods of communication will be implemented to best educate and solicit feedback from the identified stakeholders. The primary vehicle for soliciting feedback from community members and proximate neighbors to the Surfside WWTF will be two public meetings, the first of which is tentatively scheduled to be held the last week of January 2020. The intent of this first public meeting is to introduce the feasibility study, describe anaerobic digestion technology, and solicit initial commentary and reactions from the public. This feedback will be immediately considered, and new concerns will be evaluated as part of the study.

Due to the extreme seasonal variability in population on Nantucket, a second public meeting is scheduled to be held in late June 2020 to accommodate residents primarily present only in the summer months. This meeting will be held prior to completion of the Draft Feasibility Study Report such that any concerns may be addressed appropriately.

Approximately two weeks before each public meeting, an announcement will be posted on the Town's website in addition to an announcement made at the beginning of the preceding Select Board meeting indicating the details of each public meeting. As there are no direct abutters to the WWTF, flyers announcing the public meetings will be sent to neighboring property owners within 1000 feet of the WWTF. Additionally, the Town will make a public post on the Town's website on December 18, 2019 announcing the Feasibility Study and brief introduction to anaerobic digestion technology.

2.2 Project Meetings

Meetings with select stakeholders, including representatives from the Sewer Department, Town Administration, Board of Health, Energy Office, Department of Public Works, and Weston & Sampson will be held the day of, or day prior to the Public Meetings. Additional communication with these stakeholders will be managed as needed throughout the study via telephone and email updates and discussions.

Additional project meetings are anticipated between Weston & Sampson and individual and private stakeholders such as Cisco Brewers, Stop and Shop, Nantucket Cottage Hospital, Nantucket Public School District, and Food Rescue Nantucket. Communication with these stakeholders will begin in January 2020 once the technological evaluation has progressed. A meeting between Weston & Sampson, the Department of Public Works, and Waste Options Nantucket is scheduled for December 17, 2019.

2.3 Additional Outreach

Weston & Sampson is currently working with the Town to develop a page for the project to be housed on the Town's website. The page will include supplemental information on anaerobic digestion technology, source-separated organics, MassCEC's Organics-to-Energy Program, important dates for the Feasibility Study including dates of public meetings, and copies of project presentations. The website will be dynamic and can be amended as new information becomes available throughout the project. The website is scheduled to go live in early January 2020.

3.0 POTENTIAL NUISANCE CONDITIONS

While it is expected that communication with stakeholders will identify additional areas of concern and public impacts, several potential nuisance conditions were identified and discussed at the kick-off meeting. Each area of concern and response is described below.

3.1 Odor

Odor control is a consistent concern for any changes in operations at the WWTF. Specific odor control options will be evaluated as part of the feasibility study, including pre-processing odor control, digester covers, and digestate dewatering odor control. All treatment processes at the Surfside WWTF are currently covered with odor controls in place.

3.2 Visibility

While the height and volume of any proposed digesters would not be known until a final design is proposed, it is unlikely that any design will recommend digesters that will be larger than existing treatment buildings and structures at the WWTP. It is therefore not expected that any digesters would be a visual detraction from the existing site, though the size and exact location will be considered as part of the feasibility study. Should the Feasibility Study recommend and proceed to construction, any final design of additional structures at the WWTF will need to be approved by the Nantucket Historic District Commission.

3.3 Truck Traffic

Additional traffic is expected in the delivery of feedstocks, including source-separated organics, to the WWTF. However, it is expected that the volume of solids needing transport from the WWTF to the landfill will decrease and offset, at least in part, any feedstock deliveries. The specific number of trips and types of vehicles will be evaluated in the feasibility study as economic conditions and feedstock availability are better known.

4.0 PUBLIC OUTREACH EXPERIENCE

Weston & Sampson has worked with the Town of Nantucket in recent years on several project teams involving projects of varying size and scope including extensive sewer extensions and connections. For each of these projects, the Town and Weston & Sampson have seen measured success in outreach efforts to the public. Thousands of residents, part and full time, have participated in public meetings, subscribed to targeted email updates, and viewed postings on the Town’s social media pages, independent project pages on the Town’s website, monthly newsletters, and newspaper articles. The Town and Weston & Sampson will continue their record of thoughtful and successful public outreach for this Feasibility Study project.

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REPORT

August, 2020

TOWN OF
Nantucket
MASSACHUSETTS

Anaerobic Digester Feasibility Study
Community Engagement Report
UPDATE

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This report update serves to document the additional public outreach initiative undertaken as part of this project since the first submittal of the Community Engagement Report in December 2019. In feasibility studies and in any subsequent planning and design, it is imperative to evaluate community compatibility by identifying potential impacts to and concerns of the Nantucket community. Future work on this project should aim to advance public education and outreach initiatives. For outreach prior to December 2019, please revisit the December 15, 2019 Community Engagement Report.

1.0 PUBLIC MEETINGS

On February 4, 2020, the first of two public meetings was held in the Nantucket Highschool Cafeteria. Town stakeholders participated in the presentation and subsequent discussion with the four attendees from the public at large. Questions from the audience focused on anaerobic digester technology theory as well as concerns about whether this project could increase sewer capacity on the island. It was conveyed that sewer capacity would not be impacted by this project.

The second public meeting was held on July 30, 2020. Due to public health policy changes stemming from COVID-19 concerns, the meeting was broadcast live across YouTube and Zoom. While it is not know how many community members watched live, the video has been watched 74 times as of the publishing of this update report. There was further discussion after this public meeting. Discussion points were as follows:

- What is the payback period and its expected useful life?
    - Expected useful life for wastewater projects typically targets 20 years. This project was designed for twenty year use though the equipment can and often does exceed that with proper upkeep and maintenance. A traditional payback analysis is difficult on Nantucket as there are relatively few revenue streams available to this project when compared with similar projects in other communities such as tipping fees. Therefore, this project is driven more by perceived benefits on the island which are much more difficult to quantify.
- Were alternate site evaluated such as Siasconset?
    - Yes, other areas were evaluated such as Siasconset and the Composter/Landfill location. Transportation costs associated with digester feedstock the majority of which is waste sludge generated on site at the WWTP and other efficiencies and synergies in operation made the Surfside WWTF location most favorable.
- Does this project provide a reduction in green house gases compared to sending waste straight to the landfill?
    - Anaerobic digestion actually produces methane which is a potent greenhouse gas. However, when that methane used beneficially, it takes the place of fuel oil or electricity from the grid as an energy source, thereby decreasing the carbon footprint of the wastewater treatment facility when taken as a whole system. There is also an additional savings in greenhouse gases in reduced trucking needs due to reduced biosolids transportation from Surfside to the Composter in Madaket.
- Have local waste haulers expressed any opinions about this project and how it might affect their operations.
    - We have not explicitly reached out to local waste haulers explicitly for this project yet, but the DPW has been in frequent and ongoing discussions with them regarding the

Composter and MSW. It will be a major factor for consideration moving into a design phase for the project, though we are seeing that there is more value in targeting partnerships with large, organics generators, like grocery stores, rather that individual residences and their small contract waste haulers.

The meeting will remain on the Town government's YouTube channel for any further viewing.

2.0 VIRTUAL OUTREACH

Given the unprecedented COVID-19 pandemic, access to in-person meetings and conveyance of information was limited. Therefore, the Town has prioritized virtual efforts to communicate project updates with the public. The main source of information has been the project's page on the Town's website. A copy of the project page is presented in the figure below:

Home › Government › Departments O-Z › Sewer Department › Anaerobic Digester Feasibility Study

Anaerobic Digester Feasibility Study

The Town of Nantucket Sewer Department and Weston & Sampson are conducting a feasibility study to evaluate the potential for developing an organics-to-energy project at the Town-owned Surfside Wastewater Treatment Facility (WWTF) through a grant provided by the Massachusetts Clean Energy Center (MassCEC). The study will provide a determination of the technological feasibility and economic viability of adding one or more anaerobic digesters to the WWTF. If found to be feasible, the addition of anaerobic digestion technology would provide the island with an alternative source of energy, thereby decreasing energy demands and costs, as well as providing volume reduction of source separated and WWTF waste, reducing demand on the island's already limited landfill capacity.

Anaerobic digestion has been present in the United States for municipal solutions since the 1930's, and there has been a renewed interest in the technology in the last decade as a reliable source of renewable energy. Anaerobic digestion, which utilizes biological treatment, converts materials traditionally thought of as waste, including organic materials such as sewage sludge, food scraps, and fats, oils, and grease into usable heat and electricity.

Contact Us

For direct feedback on this study, you may contact:

Gina Cortese
Email
Weston & Sampson

Ph: 978-532-1900 ext. 2243

Information about anaerobic digestion technology, the project, and copies of presentations have been made available for easy public access via this page.

Additionally, the Town and its many stakeholders have leveraged official twitter accounts, monthly e-newsletters from the Town Manager, notifications on the Town's homepage, and an extra informational video on the Town's YouTube Channel.

3.0 RESPONSE TO COMMUNITY COMMENT

Following the second public meeting, a resident reached out with specific questions and items of concern. While many of the topics are covered in the Feasibility Report, the questions and responses (**in bold**) are repeated here for completeness:

1. Not long ago the Town held a Waste Summit in which the DPW conducted several Public Information Sessions on topics related to waste management and the Select Board's Strategic Planning Framework goals. These sessions included
   - Waste Collection / Hauling and Separation;
   - Compost Program and Waste Management Technologies;

- Hazardous Waste Collection;
- Construction Site, Roadside and Coastal Litter; and
- Waste Streams and Waste Summit Summary.

o Nowhere during those sessions was anaerobic digestion at the WWTF a topic of discussion.

o Additionally, the landfill is nearing the end of its useful life. Over the years, as far back as 2010, there have been memos, reports, and discussions about the future technology for handling municipal waste and recycling at the landfill. The Town's consultant, George Aronson of CommonWealth Resource Management Corporation has submitted memos and reports dating back almost a decade which address different technologies to be built at the landfill or and a few other options such as transporting waste off-island.

o Have the authors of the feasibility study reviewed and taken into consideration the information provided in the Waste Summit and Mr. Aronson's documents?
Yes, members of the project study team included DPW staff who are familiar with the capacity constraints at the Landfill as well as relevant data pertaining to the Landfill.

2. Will the anaerobic digester facility at the Waste Water Treatment Facility be in lieu of a facility at the landfill or a separate facility? If it is a stand-alone facility, can the waste stream of the island be shared with both facilities?
The AD facility is not meant to replace the landfill. The only solid waste that can be handled by the AD facility is readily degradable organic waste, a relatively small fraction of the total solids waste handled at the landfill. All other solid wastes on the island will still need to be directly routed to the Composter and Landfill facility.

    a. Is the intent to have two facilities on Nantucket dealing with waste? One at the Landfill and one at the Waste Water Treatment Facility?
    This project assess the feasibility of a new digester and potential benefits of this approach for the portion of the solids waste generated on the island that can provide the greatest benefit from it. The siting of the facility at the Surfside WWTP was identified as the most beneficial for the project based on a number of factors which are outlined in the report.

    b. Is the intent to get us all on the same page for the future of waste management for Nantucket without having "dueling" facilities – one at the Waste Water Treatment Facility and one at the location of the current Landfill?
    There is no intent to have "dueling" facilities. the evaluation was performed to assess whether there is significant advantage to employing both facilities to address the islands solid waste streams in a more advantageous manner overall than the landfill site operations alone.

    c. Is the intent to coordinate the WWTFAD system with the TON landfill future technology?
    Evaluation of future technologies that may be employed at the landfill was not the intent of this assessment. However, if and when the project progresses the additional planning and design efforts should be advised by any such changes to the landfill operation.

d. Does the timeline anticipate waiting five years until the WON agreement sunsets before seeking a new operator at the landfill to coordinate with the WWTF operation?
No the evaluation assumes current 2020 dollars for capital costs.

3. Energy production

- How much electricity is projected to be produced?
Approximately 500,000 kwhr/yr.

- Will the energy produced be directly used at the facility?
Yes, the portion of the energy not used to support the new AD facilities will be available to offset a portion of the exiting energy demands at the Surfside WWTP. Preliminary estimates do not indicate that there will be sufficient excess energy for offsite uses.

- If so, where is the cost for the transformer equipment? The project capital cost estimate includes electrical equipment and provisions for use of the electrical energy in an appropriate form.
All costs are incorporated in the cogenerator cost estimates.

- Will that power have to be converted from DC to AC? While DC generators are available, typically cogeneration facilities use AC power production for compatibility with other typical uses.
All required power generation and conversion equipment is included.

- What costs are offset by the net metering of electricity, subsidies, ITC and/or PTC as compared with just purchasing electricity at the Town's fully renewable negotiated energy aggregate cost from National Grid. Net metering bac to the Grid is not anticipated for this project.
Excess power is not anticipated.

- Is the intent to net meter any excess power generated?
Excess power is not anticipated.

- If so,will National Grid provide a credit for the net metered power?
N/A

- Since the net metered power can't be exported to the mainland grid, how will that excess power be cleaned up to be used in our island grid?
N/A

- What would be the comparison to purchasing power from National Grid at an even lower cost that isn't based on high costs per kWh using renewable energy supplies as is being done by TON? Detailed analysis of alternate energy purchase pricing structures is outside the scope of this feasibility study.

- Will the electricity generated by the equipment at the Waste Water Treatment Facility be directly used by the Waste Water Treatment Facility?

Yes

4. As to the prospect of anaerobic digestion at the Waste Water Treatment Facility, the process that is presented leads to the following comments / questions:

As I understand it, anaerobic digestion is performed using a liquid slurry. After the gas extraction, the "digestate" then must be dewatered to make a cake like what is already done with the biosolids.

- Has the existing process of producing cake included testing for the presence of any PFASs materials?
  See below

- If so, what were the readings? Please share any info.
  See below

- Once tested, what will be done with the material if the level of PFAS exceeds MASSDEP limits?
  See below

- Will it be brought to the landfill; or shipped off island.
  See below

- If the intent is to ship off island, what is the anticipated expense for doing that? Is that cost included in the operating expenses provided in the feasibility study?
  Because of the widespread historic use of PFAS, they are now expected to be encountered in our environment. Following initial federal regulations, Massachusetts recently introduced strict drinking water standards for six PFAS compounds. The science relating to the effect and fate of these compounds is still developing.

  Regulations are not yet in place related to PFAS compounds in raw wastewater, wastewater biosolids or treated effluent. However, in July 2020, EPA Region 1 and Massachusetts DEP began issuing DRAFT NPDES permits for public WWTF discharges that includes provisions for monitoring for the presence of PFAS compounds. These permit conditions are new and have yet to become fully active – due in part to the lack of an accepted test method for the compounds in wastewater and wastewater solids.

  In the case of Nantucket, PFAS discharge permit provisions are not yet in place (or even issued as draft) for the Town's wastewater facilities. It may be expected that PFAS will be present to some degree in wastes when testing is conducted, and as such the Town is presently undertaking an initiative related to PFAS on the island. The information relative to these conditions is expected to develop significantly over the coming year(s).

  As it relates to the consideration of an anaerobic digester at the Surfside WWTF, the PFAS is not considered to be a major driver. The anaerobic digestion process is not seen as compounding or exacerbating any issues related to these compounds; nor does the anaerobic digestion process offer significant opportunity to break down these compounds.

- It appears that after the anaerobic digestion process that the digestate must either be landfilled or transported off island. Hence, the assumption that this proposed option would be unlikely to save $130,000 per year. Instead, might it not cost TON to process the digestate? The Enterprise Fund could lose money on this type of operation. Is that something we ought to review further? The digestate would proceed through the current solids handling that is in operation at the WWTF now. The amount of total biosolids produced by WWTF and sent to the Composter/Landfill after AD implementation is expected to decrease by more than 30%. The biosolids will continue to be incorporated with the composter wastes. No change in composted material use is anticipated by this project.

5. As I understand it, once the slurry is converted to a sludge "cake", something must be done with the resulting digestate. USEPA and MASSDEP require that it pass what's known as a Process to Further Reduce Pathogens (PFRP) meaning composting or heat drying of some sort.
   The cake (biosolids) produced from the dewatering of the Digestate (the combined liquid and solid waste leaving the digesters) will be hauled to the landfill for composting similar to the way the current undigested dewaterd cake is handled. Similarly the liquid phase will be returned to the WWTP influent for subsequent treatment as it is now.

- At what temperature does PFAS break down, if at all?
  Current information suggests that the normal operating temperature for mesophilic anaerobic digestion is not likely to degrade PFAS compounds.

- And at what temperature would the proposed AD system run at?
  The target operating temperature for mesophilic digestion is 95deg F.

- Will the temperature of the AD process be high enough to destroy and of the various PFAS chemicals, some of which we have upon good source has already been detected in the sludge?
  See prior response.

6. In reviewing the capital cost expenses and the operating cost estimates there is a $1,200,000 estimate for operating costs shown. It's a bit vague and confusing.

- It appears that $1,200,000 to $1,600,000/yr. for amortization and operating expense which would supposedly translate into a supposed savings of about $130,000/yr. Is this financially prudent?
  Per the draft feasibility report, it is anticipated that the Sewer Department would save approximately $220,000 in electricity, heat, and disposal costs. The amortized cost plus operating expense is calculated separate from the projected costs savings.

- Has the finance department reviewed the documents? If so, can you share their views?
  No, not at this stage of the evaluation.

- Does the analysis take into account that the digestate, which may contain excessive levels of PFAS, will still have to be landfilled at a current annual cost of $83,000 (subject to escalation over time) so the net savings is closer to $47,000?
  Please see item 5 in regards to PFAS. Disposal costs savings is based on a projected net decrease in the amount of biosolids sent to the Composter/ Landfill.

- If so, then all that digestate will have to go to the landfill which means that the savings of landfill fees being described would not likely be as represented. Please address this.
  Please see above and item 2.

- Disposal cost will have to be added to the pro forma. Is this correct?
  Please see above and item 2.

7. As to the engineering costs, based on past experiences on other projects over many years, a line item for $2,500,000 seems a bit hefty without some basis or explanation.
- What is the basis for this line item? I ask because if a reasonable average hourly cost of an engineering team (executive, project manager, team members, staff, etc.) is, say, $150, then that converts to 16,600 hours. That's the equivalent of 5 engineers working full time (40 hrs./wk.) for 83 weeks. Please provide some detail relating to this line item.
  The Feasibility Study includes a detailed basis for cost projections. However, the opinion of probably cost is still a best estimate and meant to give order of magnitude pricing. Engineering costs were estimated to be 23% of the capital cost of construction. Engineering costs include engineering services during construction, permitting related assistance, bidding assistance and other support services in addition to the detailed technical design effort.

8. The inference of "organic waste streams around the island" is that there isn't enough sewage sludge available. Is that so? There currently is no clean separated food waste on the island. Therefore, it needs to be depackaged/cleaned before it can go into an AD plant.
- Where is the cost of installing and operating a depacking operation?
- The project is targeting partnerships with large, organic waste producers on the island that would agree to source separate organic (SSO) material. That said, material handling including a slurrying step for the SSO is include in the digester design as pretreatment.

- Is a depacking operation included in the current analysis?
  See above

- The Massachusetts commercial organics waste disposal ban, which applies to all business and institutions disposing of one ton or more of food waste per week took effect on October 1, 2014. How does this ban figure into the concept of a separate anerobic digester at the Waste Water Treatment Plant?
- At present, the requirements of this ban are being met by the Composter.

9. The information shared in the presentation seemed to indicate that amount of sludge generated on the island is modest and fluctuates dramatically winter to summer.
- How would an AD system operate efficiently unless it was overbuilt, with multiple tanks for the summer months and then perhaps 1/2 of it shut down in the winter?
  The operation, and the benefits of this process, are described in greater detail in the Feasibility study. However, both tanks would typically remain operational during all seasons. In high season, both would operate.. In low season, the second would provide additional storage and the ability to allow one unit to be taken out of service for cleaning which is typically required every three years or so.

- The small operation in the winter would seem to translate into a high per gallon cost, but it would be aggravated if the system were overbuilt to accommodate the heavier load in summer. Is that the intent?
  See above.

10. As to the $15,000,000 to $20,000,000 capex:
- Does the Feasibility Sturdy assume the AD system at the WWTF will capture all the organic waste that now is comingled with Municipal Solid Waste at the landfill?
  No

- Will TON have to mandate that all organic waste be separated?
  This project specifically will seek to partner with large, organic waste producers, though the analysis of feedstock availability will need to be further developed during final design.

- Has any consideration been given to putting in a tank to treat the WWTF sludge?
  The AD system specifically provides that treatment.

- Any consideration regarding putting the dewatered sludge in a dryer and compost the SSO/food waste?
  NO, drying dewatered sludge whether digested or not would increase operating energy requirements significantly over the proposed approach.

11. Will the proposed new anaerobic digestion facility at the WWTF operate under the Sewer Enterprise Fund? If so, is the intent that any operating deficit be funded by other line items within the Sewer Enterprise Fund or is the expectation that the TON will make up any deficits from other funding sources?
    All operational work is anticipated to be be done within the Enterprise Fund.

12. The new facilities would become part of the WWTF and would operate under the Sewer Enterprise Fund. Funding sources to construct the facilities will need to be determined. Will commercial haulers be required to pay tipping fees?
    Cost projections were created without the expectation of tipping fees.

13. How would the presence of PFAS chemicals in Town wells at levels higher that current MCLs play into the feasibility study costs, if at all?
    See item 5.

14. The suggestion of installing anaerobic digestion seems to not address nor resolve potential PFAS chemicals in the sludge. Has any consideration been given to investing in reverse osmosis, Ion-exchange resins, granulated activated carbon traps or some other filtration method?
    See item 5.

15. One of the slides, "Anaerobic Digestion Technology", shows a graphic of the process. The graphic shows that biogas is produced.
    a. Is this similar to syngas produced in a gasification process?

A number of technologies are available that can recover combustible gases. Anaerobic digestion from degraded waste solids in water is a long-proven process.

Can this biogas be used to power small electric generating equipment at the Waste Water Treatment Plant so the facility can be off the power grid? Yes, a primary aspect of the project is to generate heat and electrical power from the biogas to offset energy costs at the WWTF beyond that needed for the new facilities.

Can the biogas be distilled and processed into a useable product? Further processing of the biogas and or distribution off site will add costs to the project. The projected net useable heat and electrical energy is not expected to exceed the onsite demands for the site making on site use the least costly to implement.

Anaerobic Digestion Feasibility Study

Surfside Wastewater Treatment Facility

Public Meeting

February 4, 2020

Nantucket High School Cafeteria

Agenda

- Introduce CEC Organics-to-Energy Project Team
- MassCEC Assistance
- Goals
- Anaerobic Digestion Technology
- Anaerobic Digestion in Nantucket
- Schedule & Moving Forward

CEC Project Team

- David Gray, Sewer Director, Nantucket
- Roberto Santamaria, Health Director, Nantucket
- Lauren Sinatra, Energy Coordinator, Nantucket
- Kent Nichols, Weston& Sampson
- Dan Sheahan, Weston & Sampson
- Gina Cortese, Weston & Sampson
- Representative from numerous Town Departments

MassCEC Assistance

MASSACHUSETTS CLEAN ENERGY CENTER®

- State economic development agency
- Mission: grow the state's clean energy economy while helping to meet the MA's clean energy, climate and economic development goals
- 2019 Organics-to-Energy grant for Feasibility Study: $60,000
- Public Outreach Support

TOWN OF NANTUCKET MASS INCORPORATED 1671

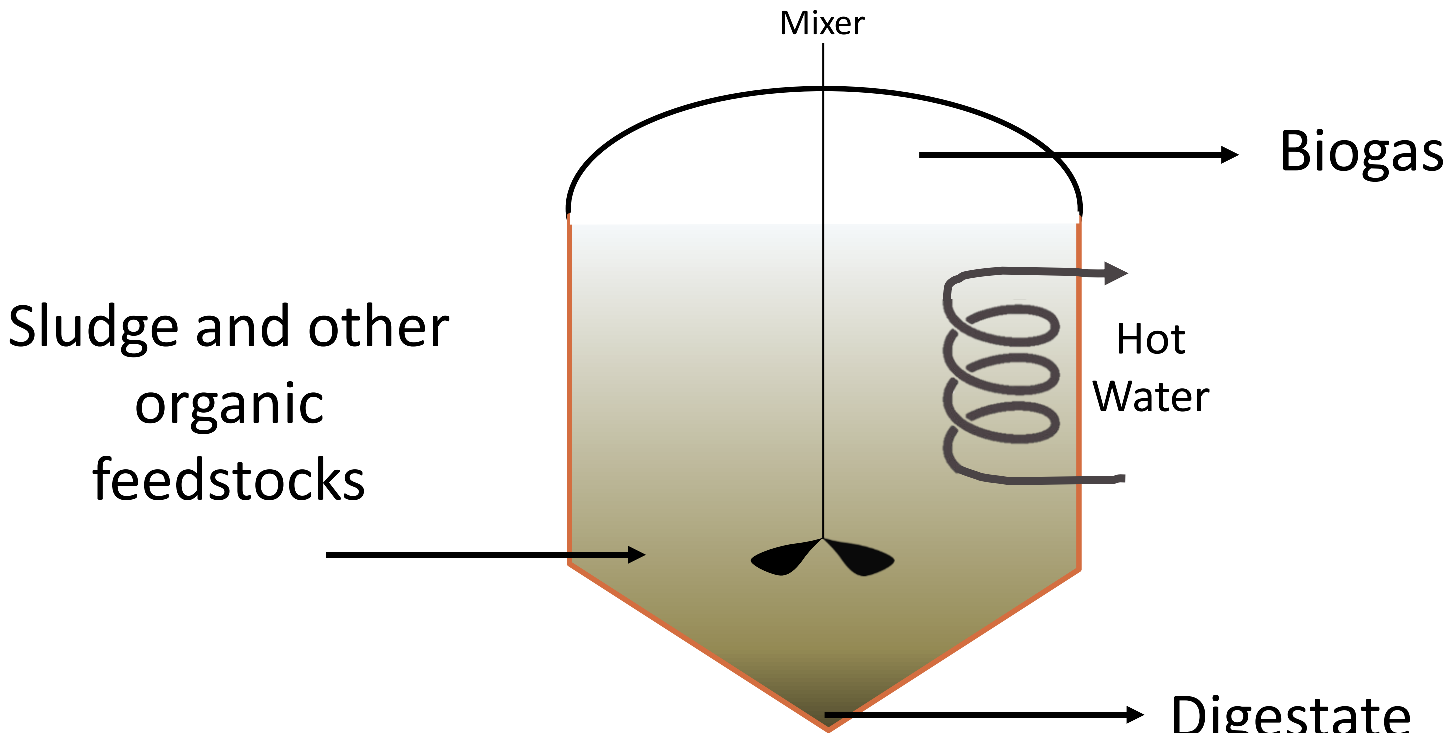
Project Goals

- Determine Feasibility of AD Based on:
  - Evaluation of Project Site, Vicinity, and Community Impacts
  - Environmental and Permitting Consideration
  - Feedstock Analysis
  - Treatment Capacity/ Headworks Analysis
  - System Output Analysis
  - Financial Evaluation
- Anaerobic Digester Conceptual Design

Anaerobic Digestion Technology

- A collection of natural biologic processes.
- Microorganisms break down biodegradable material in the absence of oxygen.
- Process used in many industrial and domestic purposes to manage waste and/or to produce fuels.
- Digestate is produced by anaerobic digestion.

Anaerobic Digestion Technology



Anaerobic Digestion Technology

Anaerobic Digestion Technology


Nashua, NH

Anaerobic Digestion Technology


Rockland, MA

Anaerobic Digestion Technology

Anaerobic Digestion Technology

Burlington, VT

Anaerobic Digestion Technology

Anaerobic Digestion Technology

Feedstocks (Input)

- WWTF Residuals (Sludge/Bio-solids)
- Fats, Oils, and Grease
- Source Separated Organics
- Brewery Waste
- Other Wastes – Septage and Landfill Leachate

Anaerobic Digestion Technology
Feedstocks (Input)

- WWTF Residuals (Sludge/Bio-solids)

Anaerobic Digestion Technology
Feedstocks (Input)

- Fats, Oils, and Grease

TOWN OF NANTUCKET MASS INCORPORATED 1671

Anaerobic Digestion Technology

Feedstocks (Input)

- Source Separated Organics

Massachusetts plans to ban commercial food waste in 2014

July 11, 2013
By Catherine Kavanaugh

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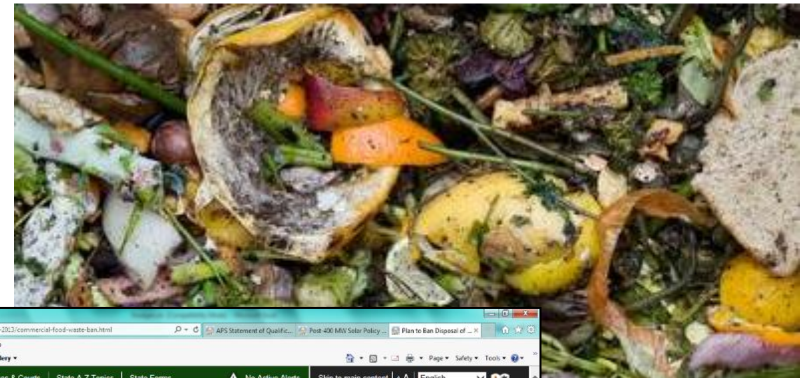
If you don't clean your plate at a Massachusetts restaurant, the scraps may not go to waste when a commercial food disposal ban goes into effect.

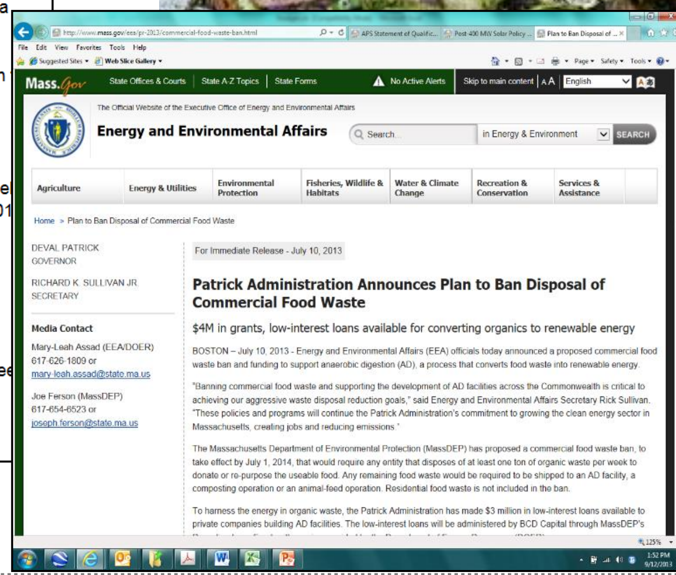
They will be turned into clean energy, officials with state's Energy and Environmental Affairs said.

Energy and Environmental Affairs announced a proposed plan that would require any entity that disposes of at least 1 ton of organic waste per wee[k] to donate or repurpose the food starting July 1, 201[4]

The ban will affect large restaurants, hospitals, universities, hotels and other big businesses and institutions.

The plan calls for food waste to be shipped to a facility that uses anaerobic digestion to covert food waste into a biogas that produces electricity and heat. Or, it can be taken to composting or animal-fee[d] operations. However, state officials are sweetening the pot for the AD option. They are offering $3 million in low-interest loans to private companies building AD facilities that harness the energy in organic waste.





http://www.mass.gov/eea/pr-2013/commercial-food-waste-ban.html

Mass.Gov State Offices & Courts | State A-Z Topics | State Forms | No Active Alerts | Skip to main content

The Official Website of the Executive Office of Energy and Environmental Affairs

Energy and Environmental Affairs

Agriculture | Energy & Utilities | Environmental Protection | Fisheries, Wildlife & Habitats | Water & Climate Change | Recreation & Conservation | Services & Assistance

Home > Plan to Ban Disposal of Commercial Food Waste

DEVAL PATRICK
GOVERNOR

RICHARD K. SULLIVAN JR.
SECRETARY

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617-654-6523 or
joseph.ferson@state.ma.us

For Immediate Release - July 10, 2013

Patrick Administration Announces Plan to Ban Disposal of Commercial Food Waste

$4M in grants, low-interest loans available for converting organics to renewable energy

BOSTON – July 10, 2013 - Energy and Environmental Affairs (EEA) officials today announced a proposed commercial food waste ban and funding to support anaerobic digestion (AD), a process that converts food waste into renewable energy.

"Banning commercial food waste and supporting the development of AD facilities across the Commonwealth is critical to achieving our aggressive waste disposal reduction goals," said Energy and Environmental Affairs Secretary Rick Sullivan. "These policies and programs will continue the Patrick Administration's commitment to growing the clean energy sector in Massachusetts, creating jobs and reducing emissions."

The Massachusetts Department of Environmental Protection (MassDEP) has proposed a commercial food waste ban, to take effect by July 1, 2014, that would require any entity that disposes of at least one ton of organic waste per week to donate or re-purpose the useable food. Any remaining food waste would be required to be shipped to an AD facility, a composting operation or an animal-feed operation. Residential food waste is not included in the ban.

To harness the energy in organic waste, the Patrick Administration has made $3 million in low-interest loans available to private companies building AD facilities. The low-interest loans will be administered by BCD Capital through MassDEP's

Anaerobic Digestion Technology
Feedstocks (Input)

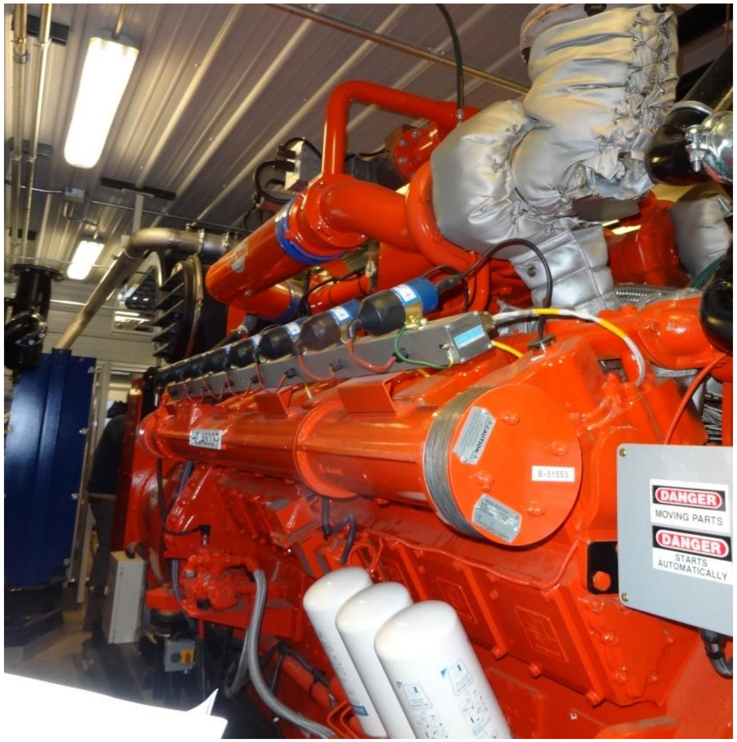
- Brewery Waste

Anaerobic Digestion Technology
Feedstocks (Input)

- Other Wastes – Septage and Landfill Leachate

Anaerobic Digestion Technology

Energy Production (Output)



Electricity

Heat

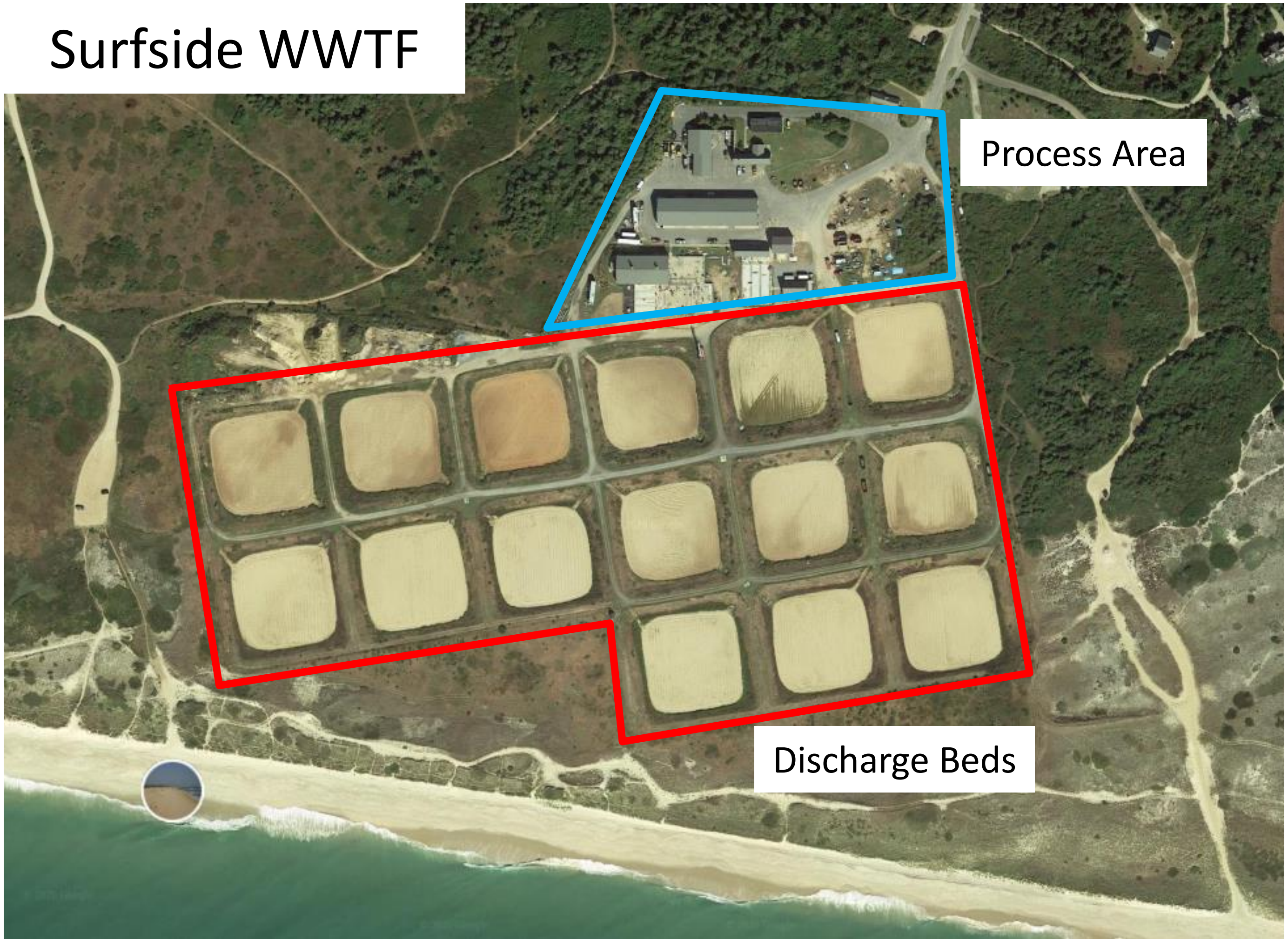
Anaerobic Digestion Technology
Class A Biosolids (Output)

Enclosed areas for roll off containers

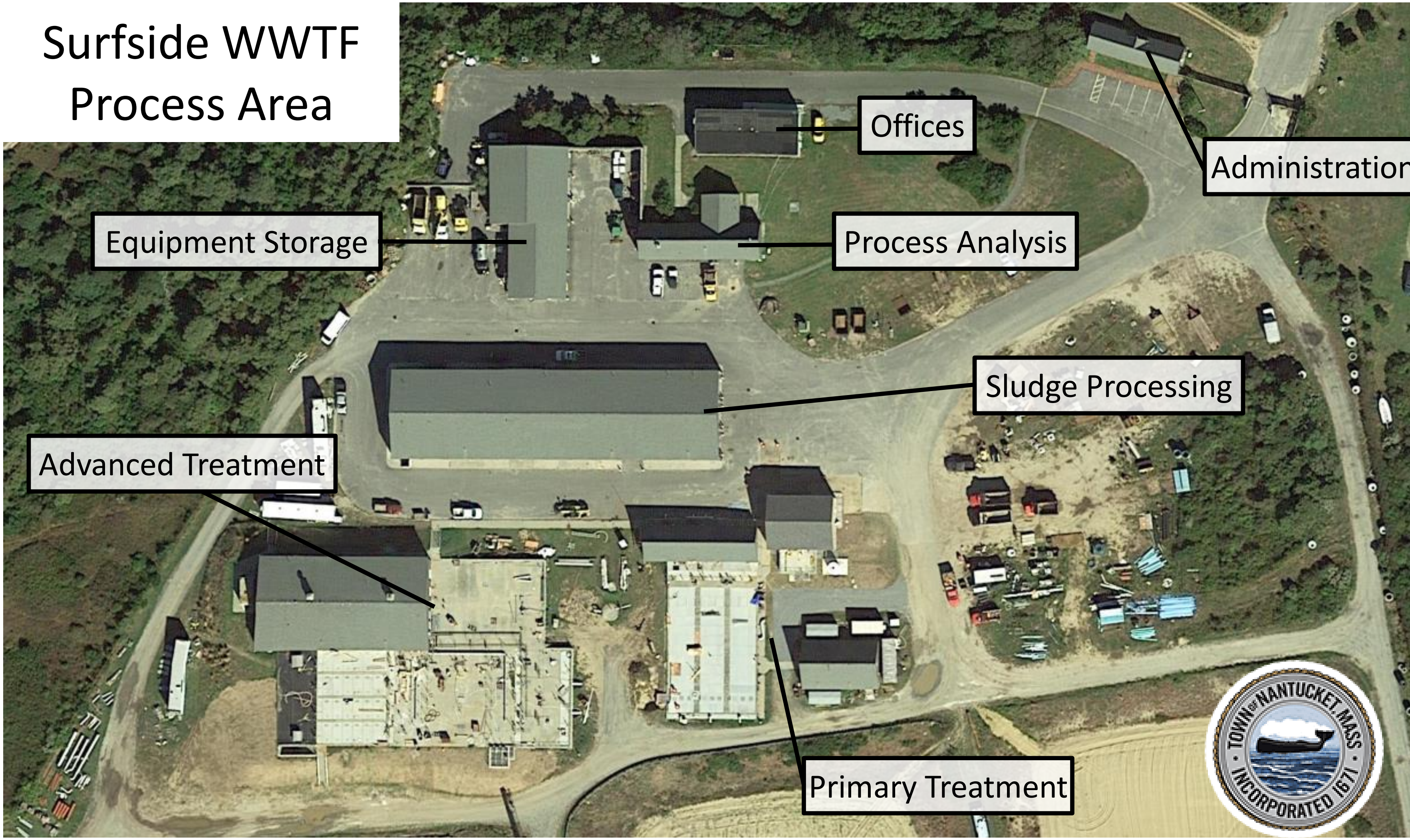
Anaerobic Digestion in Nantucket

Weston & Sampson

Anaerobic Digestion in Nantucket



Anaerobic Digestion in Nantucket



Anaerobic Digestion in Nantucket

- Possible Inputs
  - Surfside WWTF Sludge
  - Siasconset WWTF Sludge
  - FOG from restaurants, schools, other private kitchens, collection system
  - Source Separated Organics from restaurants, schools, hospital, Stop and Shop, other grocery markets, private kitchens
  - Cisco Brewery Waste
  - Other Wastes

Anaerobic Digestion in Nantucket

- Anticipated Benefits
  - Generate clean, renewable energy
  - Heating/electricity cost savings at WWTF
  - Reduce volume of solids sent to composting/ landfill
  - Improve quality of solids sent to composting/ landfill
  - Possible strength reduction of wastes to WWTF

Anaerobic Digestion in Nantucket

- Common Concerns
  - Increased Traffic
  - Odor Generation
  - Visual Impacts

Schedule

- Initial Public Meeting: February 4, 2020
- Second Public Meeting: Early Summer 2020
- Draft Feasibility Study: July 30, 2020
- Final Feasibility Study: October 30, 2020

Moving Forward

- Data Collection & Future Needs Analysis
- Conceptual Design & Model
- Environmental Analysis and Permitting Review
- Economic Analysis
- Public Comment
- Report


thank you

Anaerobic Digestion Feasibility Study

Surfside Wastewater Treatment Facility

Public Meeting

https://youtu.be/fF4ydI_uXxs

July 30, 2020

Agenda

- Project Team
- Review of Project Goals
- Review of Anaerobic Digestion
- Feasibility Methodology & Analysis
- Conceptual Design
- Schedule & Moving Forward
- Questions & Comments

CEC Project Team

- David Gray, Sewer Director, Nantucket
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Project Goals

- Determine Feasibility of AD Based on:
  - Feedstock Availability
  - Treatment Capacity
  - Energy Production
  - Waste Production
  - Financial Analysis
  - Evaluation of Project Site, Vicinity, and Community Impacts
  - Environmental and Permitting Consideration

- Anaerobic Digester Conceptual Design

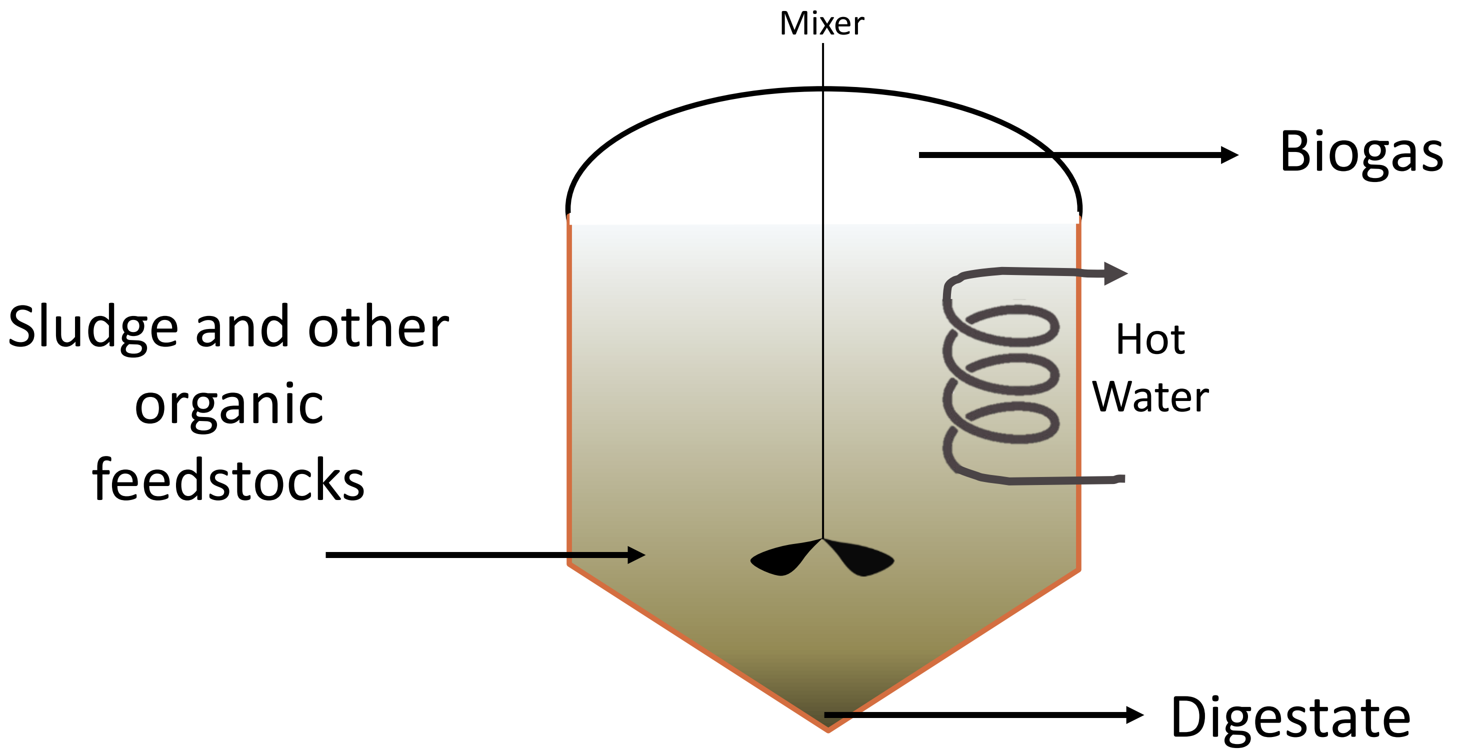
Anaerobic Digestion Benefits

1. Create sustainable energy source and cost savings for WWTF
2. Reduce volume of waste sent to Composter/ Landfill
3. Stabilize and increase nutrients in WWTF solids

Anaerobic Digestion Technology

- A collection of natural biologic processes.
- Microorganisms break down biodegradable material in the absence of oxygen.
- Process used in many industrial and domestic purposes to manage waste and/or to produce fuels.
- Digestate is produced by anaerobic digestion.

Anaerobic Digestion Technology



Anaerobic Digestion Technology
Feedstocks (Input)

- WWTF Residuals (Sludge/Bio-solids)
- Fats, Oils, and Grease
- Source Separated Organics
- Brewery Waste
- Other Wastes – Septage and Landfill Leachate

Feedstock Identification

- Identified possible feedstocks and volumes
- Data from WWTF & Landfill Records

Currently Received at Landfill	
Waste Name	Est. Ave. Annual Volume tons/yr
Municipal Solid Waste (MSW)/ Source Separated Organics (SSO)	575
Yard Waste	14,000
Animal Waste	180

Currently Available or Received by Truck at Surfside WWTF	
Waste Name	Est. Ave. Annual Volume gal/yr
FOG/ Grease Trap	8,900
Animal Grooming Trucks	165
Residential Tight Tank	336,000
Domestic Septage	1,760,000
Food Truck Waste	3,360
Equipment Cleaning Plant Water	165
Carpet Cleaner Waste	15,000
Industrial Wastes (Cisco)	133,000
Landfill Leachate	1,900,000
WWTF Sludge	2,330,000

Feedstock Identification

Currently Received at Landfill	
Waste Name	Est. Ave. Annual Volume tons/yr
Municipal Solid Waste (MSW)/ Source Separated Organics (SSO)	575

- Difficult to quantify portion of MSW/SSO available to digester
- First attempted to quantify all organic waste generators
  - Food Asset Network (2017 WPI)
  - Contact large, individual organic waste generators
    - Schools, grocery, hospital, farms, etc.
    - Positive, but inconclusive responses

Feedstock Identification

Currently Received at Landfill	
Waste Name	Est. Ave. Annual Volume tons/yr
Municipal Solid Waste (MSW)/ Source Separated Organics (SSO)	575

- Made estimation of digestible wastes present in MSW otherwise sent to Composter
- Assumptions:
  - 20% current MSW is digestible
  - 25% of digestible MSW could be reasonably diverted to WWTF
    - Commercial kitchens, grocery, etc.
- 575 tons/year of MSW/SSO

Feedstock Identification

- Characterized organic content of each
- Made recommendations

Waste Name	Estimated Average Annual Volume (liquid, gal/yr; solid, tons/yr)	Organic Content Strength (High, Moderate. Low)	Gas Production Potential (High, Moderate. Low)	Recommended as Feedstock? (Yes, No)
FOG/ Grease Trap	8,900*	High	High	Yes
Animal Grooming Trucks	165	Low	Low	No
Residential Tight Tank	336,000	Low	Low	No
Domestic Septage	1,760,000	Low	Low	No
Food Truck Waste	3,360	Low	Low	No
Equipment Cleaning Plant Water	165	Low	Low	No
Carpet Cleaner Waste	15,000	Low	Low	No
Industrial Wastes (Cisco)	133,000	High	Moderate/ High	Yes
Landfill Leachate	1,900,000	Low	Low/ Moderate	No
WWTF Sludge	2,334,000	High	Moderate/ High	Yes
MSW/ SSO	575	High	Moderate/ High	Yes
Yard Waste	14,000	Low	Low/ Moderate	No
Animal Waste	180	Low	Low/ Moderate	No

Electrical Energy Production

Source	Energy Yield (KWhr/yr)	Elec. Energy Value
Sewage Sludge	241,000	$69,000/year
Other Feedstocks	114,000	$33,000/year
Total	**355,000**	**$102,000/year**

- After Digester power loads are satisfied
- Available for WWTF demand offset
- Assumptions:
  - Approximate Elec. Energy Value @ $0.28/KWhr
  - Energy content of feedstocks from industry standards

Heat Production

Source	Energy Yield (MBTU/yr)	Equivalent Heating Oil	Cost Savings
Sewage Sludge	1,150	8230	$22,000
Other Feedstocks	540	3870	$10,000
Total	**1,690**	**12,100 gal/yr**	**$32,000/yr**

- After Digester heating is satisfied
- Available for WWTF building heating
- Assumptions:
  - Energy content of feedstocks from industry standards
  - Approximate Average $2.67/gal oil cost

Digestate & Biosolids

Feedstock Solids (High Season):

- Total Solids = 5,600 lbs/d
- Volatile Solids = 4,300lbs/d (78%)

Solids Destruction:

- Volatile Solids Destroyed = 2,500 lbs/d
  - 58% Volatile Solids destruction
  - 45% Total Solids destruction

Sludge Cake Solids Produced: 1,100 t/yr

Net Reduction in Sludge to the Composter: 320t/yr

- 35%*

* Lower % reduction than TS destruction due to addition of outside feedstocks.

Impact to Surfside WWTF Process

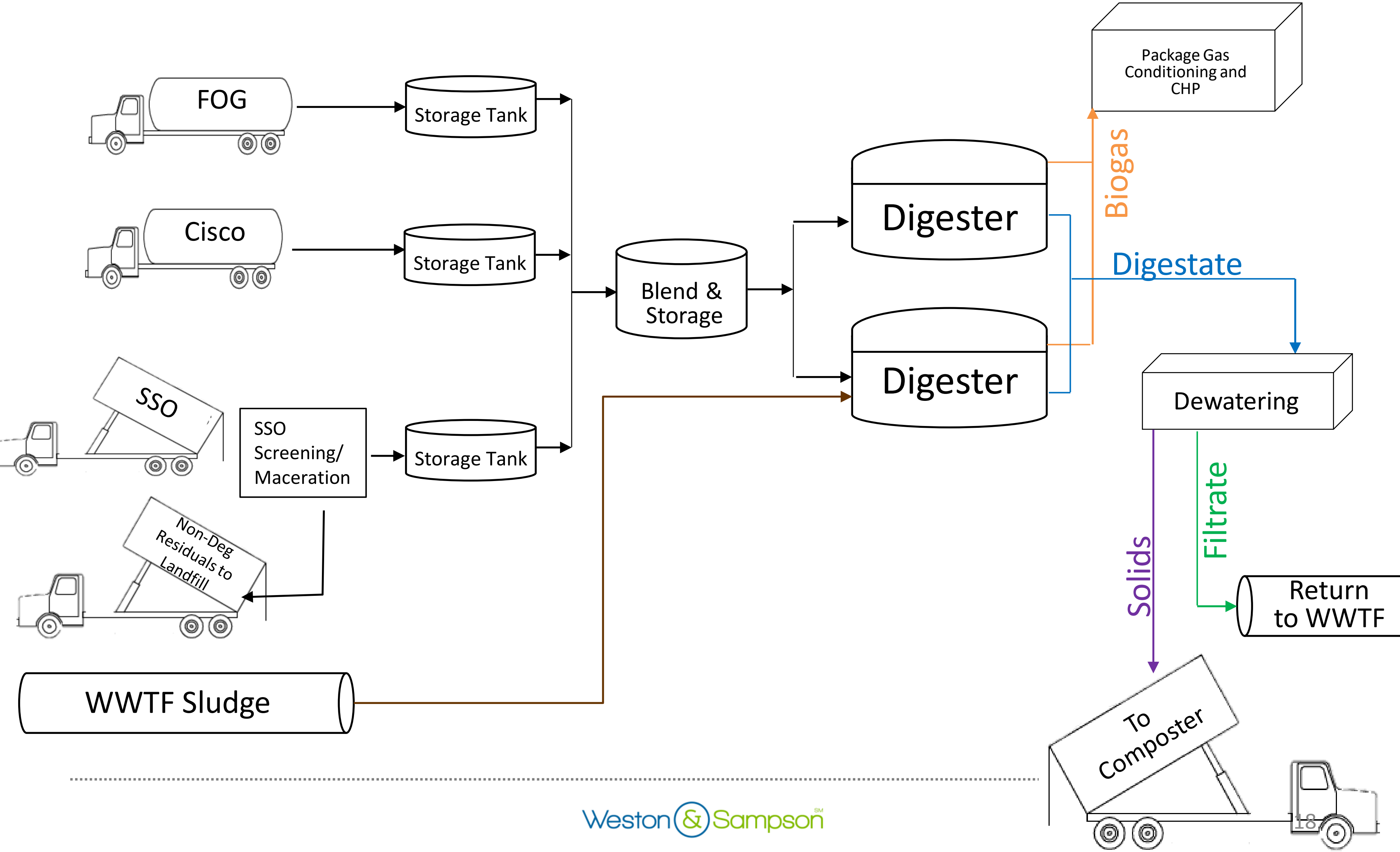
Digestate Liquid Returned to Influent

		High Season*	Low Season
Volume	(gpd)	10,000	5000
TSS	lb/d	155	75
	% increase in influent	4%	4%
NH_3-N	lb/d	95	46
	% increase in influent	15%	15%

- Reduced Solids Dewatering time due to reduced solids to dewater after digestion.

* Plant currently at approximately 50% capacity during high season. Current Plant design capacity did not include digestate return load.

Conceptual Digestion Design



Gas Processing/ Co-Gen Systems

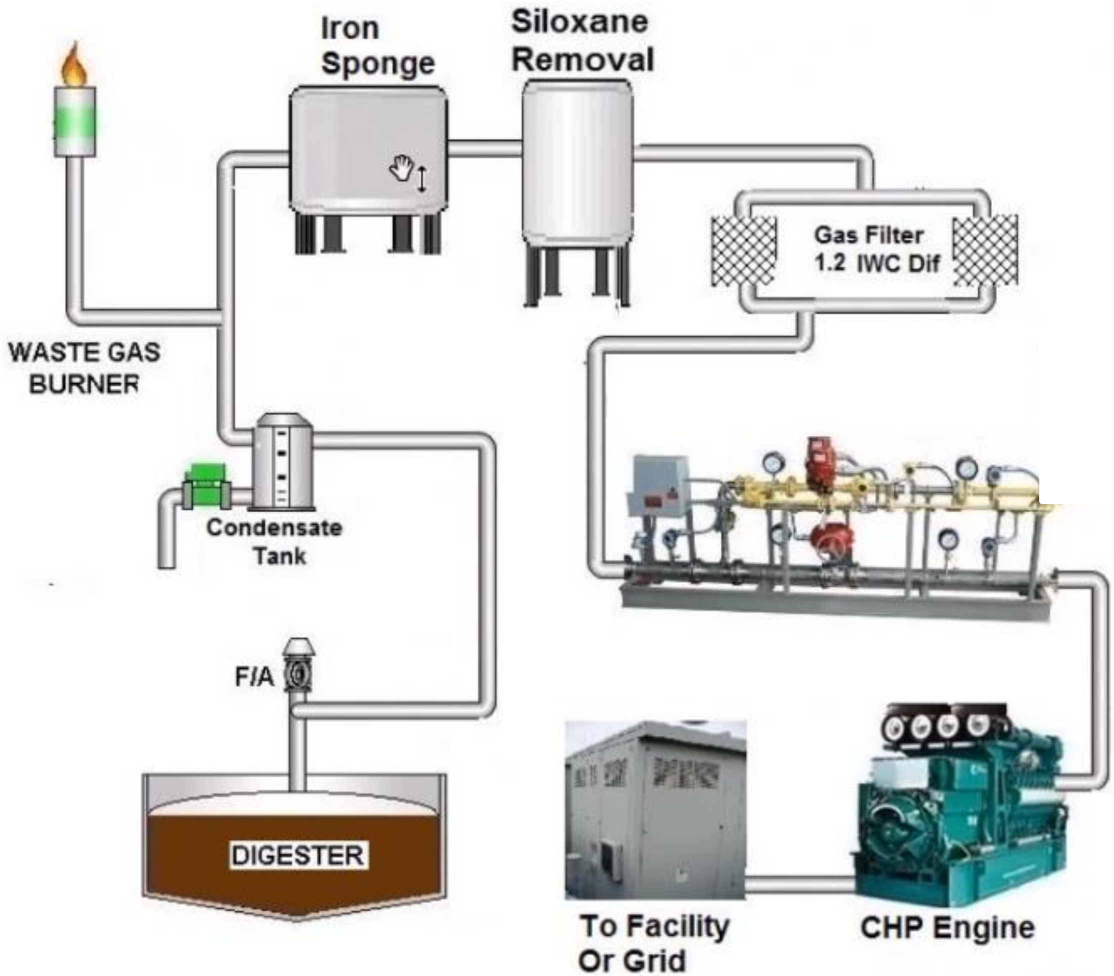


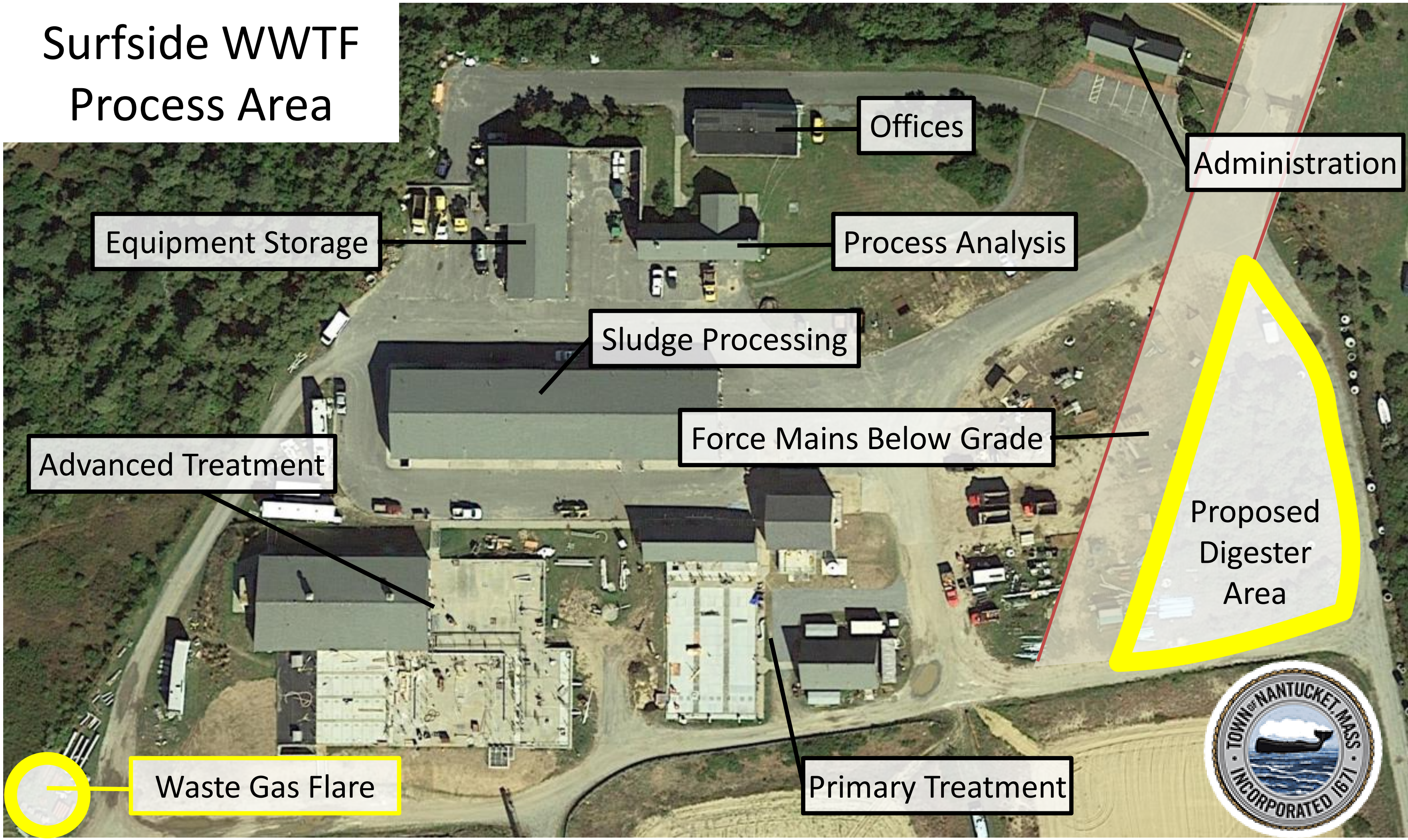
Figure from Water Environment Federation

Conceptual Design

- Construction:
  - 2 Buildings – SSO Receiving and Processing Building & Digester Support Building
    - 2,000ft^2
    - Slab-on-grade
    - Single story
  - 3 Underground storage tanks – Feedstock Storage
    - 5000-gallon each
    - Precast concrete
    - FOG, Brew Waste, SSO
  - 1 Underground storage tank – Feedstock Blend Tank
    - 2000-gallon
    - Precast concrete
    - FOG, Brew Waste, SSO
  - 2 Digesters
    - 200,000-gallon each
    - 40ft D x 28ft H
  - Site Piping Modifications
  - Site Work (associated pavement, piping, earthwork etc.)

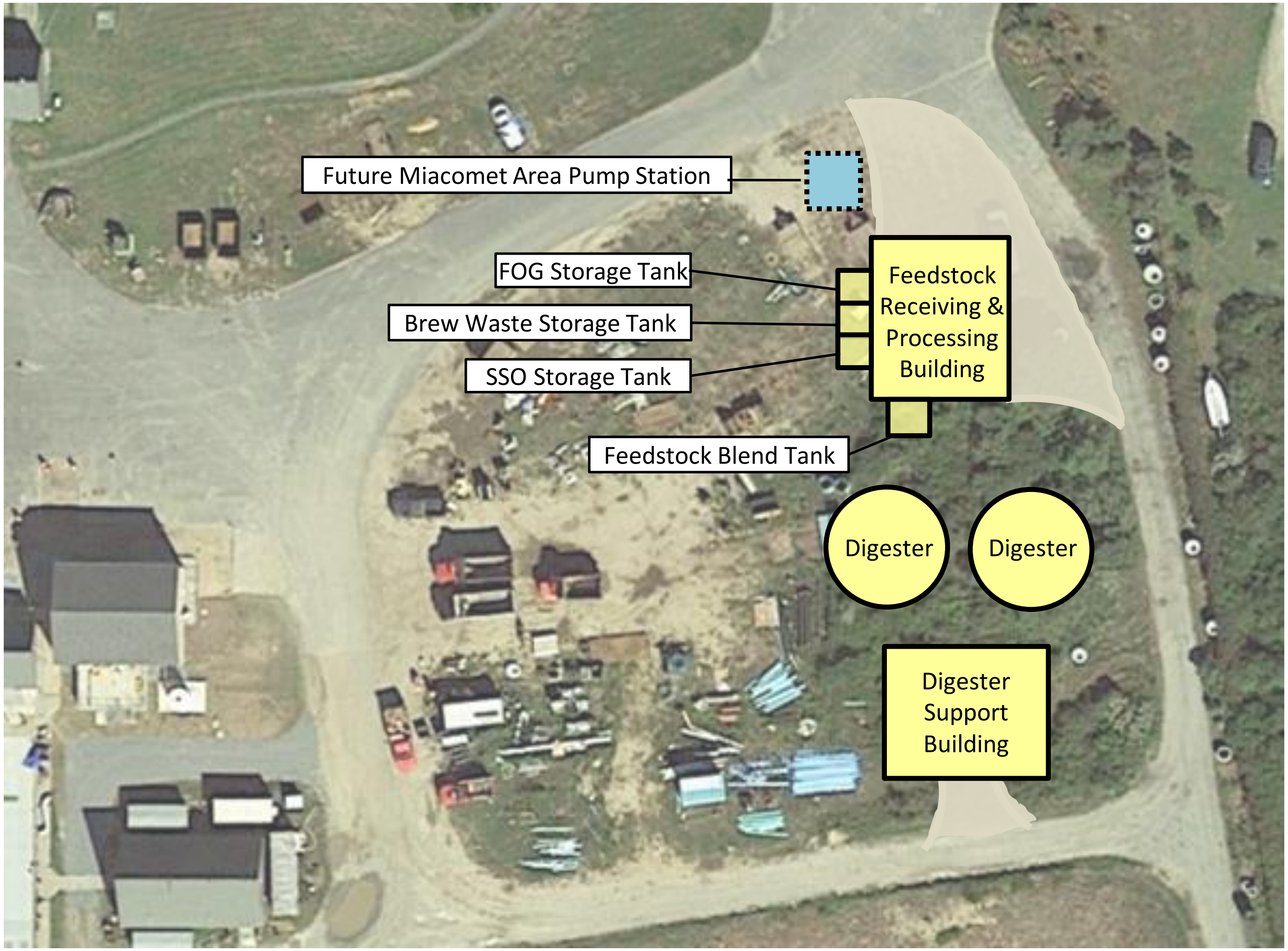
Conceptual Design

Conceptual Design



Weston & Sampson

Conceptual Design



Anaerobic Digestion Technology

Conceptual Design Costs

	Approximate Cost	
Description	**Low**	**High**
General Conditions	$1,433,000	$1,911,000
Site Work	$814,000	$1,085,000
Concrete	$825,000	$1,100,000
Buildings	$2,759,000	$3,678,000
Process Equipment	$3,179,000	$4,238,000
Exterior Finishes & Equip.	$195,000	$262,000
Controls & Instrumentation	$185,000	$246,000
Total Capital Cost	**$9,390,000**	**$12,520,000**
Engineering & Permitting	$2,160,000	$2,880,000
Planning Contingency (30%)	$3,465,000	$4,620,000
Total	**$15M**	**$20M**

Conceptual Design Costs

	Approximate Cost	
Description	**Low**	**High**
Total Opinion of Project Cost	$15,000,000	$20,000,000
Anticipated Annual O&M Cost	$300,000	$400,000
Amortized Capital Cost	$870,000	$1,160,000
Equivalent Uniform Annual Cost	**$1,170,000**	**$1,560,000**
(Approx. Annual Cost of Ownership)		

Financial Analysis

- Conceptual Level Capital Cost - $15M - $20M
- Equivalent Uniform Annual Cost: $1.2M - $1.6M
- O&M Costs
  - Labor and Parts
  - Likely Energy Neutral
    - excess heat and power will support ancillary structure heating and lights and possibly some WWTP supplement
- Savings
  - Sludge Disposal At Landfill (@$83.53/t)
    - $25,000 annually*
  - Excess Heat and Power Use
    - $84,000 excess energy annually
    - $32,000 heating oil cost savings annually

* Assumes composter currently achieves approx. 30% Sludge VS destruction (approx. 50% of AD digester reduction).

Financial Analysis

Possible Revenues

- Renewable Energy Credits
- Alternative Energy Credits
- Feedstock Tipping Fees
- Biosolids Product

Funding Sources

- Low Interest Loans SRF
- SRF Grants
- Green Energy Grants
- Organics-to-Energy Grants
- Other Grants (TBD)

Evaluation Criteria

- Evaluation Criteria & Importance
  - Capital Cost
  - Cost Savings/Revenue Generation Potential
  - Impacts to Neighbors (Visual & Odor potential)
  - Operational Complexity
  - WWTF Site Impacts
  - Landfill Life
  - Composter Impacts
  - Sensitive Environmental Receptors
  - Environmental Stewardship

Schedule

Completed:

- Kick-Off Meeting with Project Team: November 21, 2019
- Community Engagement Report: December 15, 2019
- Initial Public Meeting: February 4, 2020
- Internal Update Call: March 3, 2020
- 2nd Internal Update Call: July 13, 2020
- Second Public Meeting: July 30, 2020

Remaining:

- Draft Feasibility Study: August 30, 2020
- Final Feasibility Study: October 30, 2020

Moving Forward

- Complete Draft Report & Address Public Comments
- Town Review of Draft
- MassCEC Review of Draft
- Complete Final Report

Questions & Comments

- Receipt by August 13, 2020
- Project Page of Nantucket Town Website

https://www.nantucket-ma.gov/1616/Anaerobic-Digester-Feasibility-Study

Home › Government › Departments O-Z › Sewer Department › Anaerobic Digester Feasibility Study

Anaerobic Digester Feasibility Study

The Town of Nantucket Sewer Department and Weston & Sampson are conducting a feasibility study to evaluate the potential for developing an organics-to-energy project at the Town-owned Surfside Wastewater Treatment Facility (WWTF) through a grant provided by the Massachusetts Clean Energy Center (MassCEC). The study will provide a determination of the technological feasibility and economic viability of adding one or more anaerobic digesters to the WWTF. If found to be feasible, the addition of anaerobic digestion technology would provide the island with an alternative source of energy, thereby decreasing energy demands and costs, as well as providing volume reduction of source separated and WWTF waste, reducing demand on the island's already limited landfill capacity.

Anaerobic digestion has been present in the United States for municipal solutions since the 1930's, and there has been a renewed interest in the technology in the last decade as a reliable source of renewable energy. Anaerobic digestion, which utilizes biological treatment, converts materials traditionally thought of as waste, including organic materials such as sewage sludge, food scraps, and fats, oils, and grease into usable heat and electricity.

Contact Us

For direct feedback on this study, you may contact:

Gina Cortese
Email
Weston & Sampson

Ph: 978-532-1900 ext. 2243


thank you

APPENDIX D

Opinion of Probable Cost

Nantucket, MA - Anaerobic Digester Feasibility Study

Preliminary Opinion of Project Cost

Item No.	Description	Unit	Est. Qty.	Cost/Unit	Total Cost	Cost Ref. Date	Corresp. ENR-CCI	Current ENR-CCI	Extended Cost	"Nantucket Factor"	Final Cost	
1	**General Conditions**											
	Mobilization/Demobilization	L.S.	1	$ 539,350	$ 539,400	Aug-20	11636.56	11636.56	$ 539,400.00	1	$ 540,000.00	
	Bonds and Insurance (8%)	L.S.	1	$ 862,960	$ 863,000	Aug-20	11636.56	11636.56	$ 863,000.00	1	$ 863,000.00	
	General Conditions (5%)	L.S.	1	$ 539,350	$ 539,400	Aug-20	11636.56	11636.56	$ 539,400.00	1	$ 540,000.00	
	General Conditions Sub-total										**$ 1,943,000.00**	
2	**Site Work**											
	Excavation (Structural):											
	- Digesters	C.Y.	7,500	$ 25	$ 187,500	May-17	10692.17	11636.56	$ 204,061.01	1.5	$ 307,000.00	
	- SSO Building	C.Y.	350	$ 25	$ 8,800	May-17	10692.17	11636.56	$ 9,577.26	1.5	$ 15,000.00	
	- Gas Processing Building	C.Y.	350	$ 25	$ 8,800	May-17	10692.17	11636.56	$ 9,577.26	1.5	$ 15,000.00	
	- Waste Gas Burner	C.Y.	25	$ 25	$ 600	May-17	10692.17	11636.56	$ 653.00	1.5	$ 1,000.00	
	Backfill and Compaction:											
	- Digesters	C.Y.	5,300	$ 45	$ 238,500	May-17	10692.17	11636.56	$ 259,565.60	1.5	$ 390,000.00	
	- SSO Building	C.Y.	50	$ 45	$ 2,300	May-17	10692.17	11636.56	$ 2,503.15	1.5	$ 4,000.00	
	- Gas Processing Building	C.Y.	50	$ 45	$ 2,300	May-17	10692.17	11636.56	$ 2,503.15	1.5	$ 4,000.00	
	- Waste Gas Burner	C.Y.	20	$ 45	$ 900	May-17	10692.17	11636.56	$ 979.49	1.5	$ 2,000.00	
	8" D.I. MJ Sludge Piping	L.F.	720	$ 110	$ 79,200	Dec-18	11093.47	11636.56	$ 83,077.30	1.5	$ 125,000.00	
	6" D.I. MJ Process Water Line	L.F.	1,200	$ 100	$ 120,000	Dec-18	11093.47	11636.56	$ 125,874.70	1.5	$ 189,000.00	
	4" HDPE Gas Line to Waste Gas Burner	L.F.	880	$ 80	$ 70,400	Dec-18	11093.47	11636.56	$ 73,846.49	1.5	$ 111,000.00	
	6' Diameter Gas Line Condensate Trap MH	L.S.	1	$ 8,000	$ 8,000	Dec-18	11093.47	11636.56	$ 8,391.65	1.5	$ 13,000.00	
	8" SDR-35 PVC Plant Sewer Line	L.S.	450	$ 100	$ 45,000	Dec-18	11093.47	11636.56	$ 47,203.01	1.5	$ 71,000.00	
	1" HDPE WGB Pilot Gas Line from LP Tank	L.F.	100	$ 50	$ 5,000	Dec-18	11093.47	11636.56	$ 5,244.78	1.5	$ 8,000.00	
	4' Pre-cast Concrete Sewer Manhole	L.S.	2	$ 6,500	$ 13,000	Dec-18	11093.47	11636.56	$ 13,636.43	1.5	$ 21,000.00	
	Site Grading	C.Y.	2,500	$ 3	$ 7,500	Dec-18	11093.47	11636.56	$ 7,867.17	1.5	$ 12,000.00	
	3/4 Crushed Gravel Pavement Sub-Base	C.Y.	275	$ 40	$ 11,000	Dec-18	11093.47	11636.56	$ 11,538.51	1.5	$ 18,000.00	
	4" Asphalt Paving	S.Y.	550	$ 30	$ 16,500	Dec-18	11093.47	11636.56	$ 17,307.77	1.5	$ 26,000.00	
	Restoration of Growth (Lawn)	MSF	45	$ 200	$ 9,000	Dec-18	11093.47	11636.56	$ 9,440.60	1.5	$ 15,000.00	
	Footing Drain (pipe, stone, filter fabric)	L.F.	660	$ 50	$ 33,000	Dec-18	11093.47	11636.56	$ 34,615.54	1.5	$ 52,000.00	
	Above Ground Piping Supports	L.S.	1	$ 5,000	$ 5,000	Dec-18	11093.47	11636.56	$ 5,244.78	1.5	$ 8,000.00	
	Rented Propane Tank Install	L.S.	1	$ 10,000	$ 10,000	Dec-18	11093.47	11636.56	$ 10,489.56	1.5	$ 16,000.00	
	Sitework Sub-total										**$ 1,085,000**	
3	**Concrete**											
	Waste Gas Burner Pedestal	C.Y.	10	$ 600	$ 6,000	Dec-18	11093.47	11636.56	$ 6,293.73	1.5	$ 10,000.00	
	Waste Gas Burner Condensate Trap MH	L.S.	1	$ 6,500	$ 6,500	Dec-18	11093.47	11636.56	$ 6,818.21	1.5	$ 11,000.00	
	Pre-cast 10,000 Gal. SSO Receiving Tank	L.S.	1	$ 30,000	$ 30,000	Dec-18	11093.47	11636.56	$ 31,468.67	1.5	$ 48,000.00	
	Pre-cast 2,000 Gal. FOG Waste Receiving Tank	L.S.	1	$ 15,000	$ 15,000	Dec-18	11093.47	11636.56	$ 15,734.34	1.5	$ 24,000.00	
	Pre-cast 5,000 Gal. Brewery Waste Receiving Tank	L.S.	1	$ 20,000	$ 20,000	Dec-18	11093.47	11636.56	$ 20,979.12	1.5	$ 32,000.00	
	Pre-cast 5,000 Gal.Digester Feed Blend Tank	L.S.	1	$ 20,000	$ 20,000	Dec-18	11093.47	11636.56	$ 20,979.12	1.5	$ 32,000.00	
	Digester Base Slabs (Cone Sections)	C.Y.	150	$ 600	$ 90,000	Dec-18	11093.47	11636.56	$ 94,406.02	1.5	$ 142,000.00	
	Wall Panel Grout (base - digesters and digestate tank)	C.Y.	20	$ 500	$ 10,000	Dec-18	11093.47	11636.56	$ 10,489.56	1.5	$ 16,000.00	
	Digestate Thickener Base Slab	C.Y.	30	$ 600	$ 18,000	Dec-18	11093.47	11636.56	$ 18,881.20	1.5	$ 29,000.00	
	Pre-stressed Concrete Digestate Tank Pannels	L.S.	1	$ 65,000	$ 65,000	Aug-20	11636.56	11636.56	$ 65,000.00	1	$ 65,000.00	
	Digestate Tank Pre-stressed Hollow Core and Hatch	L.S.	1	$ 25,000	$ 25,000	Aug-20	11636.56	11636.56	$ 25,000.00	1	$ 25,000.00	
	Placement of Pre-stressed Conc. Wall Panels	Ea.	1	$ 30,000	$ 30,000	Aug-20	11636.56	11636.56	$ 30,000.00	1	$ 30,000.00	
	Digester Cover Ballast Concrete	C.Y.	5	$ 500	$ 2,500	Dec-18	11093.47	11636.56	$ 2,622.39	1.5	$ 4,000.00	
	Pre-stressed Concrete Wall Panels, Delivered	L.S.	1	$ 660,000	$ 660,000	Aug-20	11636.56	11636.56	$ 660,000.00	1	$ 660,000.00	
	Placement of Pre-stressed Conc. Wall Panels	Ea.	1	$ 150,000	$ 150,000	Aug-20	11636.56	11636.56	$ 150,000.00	1	$ 150,000.00	
	Building Footings, Frost Walls, Slabs	*(Included in Building Square Foot Costs)*										
	Concrete Sub-total										**$ 1,278,000**	
4	**Buildings**											
	Masonry SSO Receiving Building, Shake Siding	S.F.	2,000	$ 820	$ 1,640,000	Jul-16	10379.26	11636.56	$ 1,838,662.72	1	$ 1,839,000.00	*Costs based*

Nantucket, MA - Anaerobic Digester Feasibility Study

Preliminary Opinion of Project Cost

Item No.	Description	Unit	Est. Qty.	Cost/Unit	Total Cost	Cost Ref. Date	Corresp. ENR-CCI	Current ENR-CCI	Extended Cost	"Nantucket Factor"	Final Cost	
	Masonry Gas Processing Building, Shake Siding *(Includes all Electrical, Lighting, HVAC)*	S.F.	2,000	$ 820	$ 1,640,000	Jul-16	10379.26	11636.56	$ 1,838,662.72	1	$ 1,839,000.00	*Costs basea*
	Buildings Sub-total										**$ 3,678,000**	
5	**Equipment**											
	Digesters:											
	Sludge Recirculation Pump	Ea.	2	$ 25,000	$ 50,000	Dec-18	11093.47	11636.56	$ 52,447.79	1	$ 53,000.00	
	Seal Water Manifold	Ea.	2	$ 4,600	$ 9,200	Dec-18	11093.47	11636.56	$ 9,650.39	1	$ 10,000.00	
	Cover Position Indicator/Transmitter	Ea.	2	$ 16,000	$ 32,000	Dec-18	11093.47	11636.56	$ 33,566.59	1	$ 34,000.00	
	Gas Safety Equipment (In Building)	L.S.	1	$ 200,000	$ 200,000	Dec-18	11093.47	11636.56	$ 209,791.17	1	$ 210,000.00	
	Gas Safety Equipment (On Digester Covers)	L.S.	1	$ 150,000	$ 150,000	Dec-18	11093.47	11636.56	$ 157,343.37	1	$ 158,000.00	
	Sludge Heat Exchanger	Ea.	2	$ 80,000	$ 160,000	Dec-18	11093.47	11636.56	$ 167,832.93	1	$ 168,000.00	
	Radial Beam Floating Digester Gasholder Cover	Ea.	2	$ 202,000	$ 404,000	Dec-18	11093.47	11636.56	$ 423,778.15	1	$ 424,000.00	
	Cover-mounted Linear Motion Digester Mixer	Ea.	2	$ 209,000	$ 418,000	Dec-18	11093.47	11636.56	$ 438,463.54	1	$ 439,000.00	
	Equipment Installation	L.S.	1	$ 221,700	$ 221,700	Dec-18	11093.47	11636.56	$ 232,553.51	1.5	$ 349,000.00	
	Digester Cover Roof Membrane and Insulation System	S.F.	1,900	$ 40	$ 76,000	Dec-18	11093.47	11636.56	$ 79,720.64	1.5	$ 120,000.00	
	Digesters Electrical	L.S.	1	$ 50,000	$ 50,000	Aug-20	11636.56	11636.56	$ 50,000.00	1.5	$ 75,000.00	
	Process and Gas Piping											
	6" Insulated Digester Gas Suction Piping	L.F.	200	$ 250	$ 50,000	Dec-18	11093.47	11636.56	$ 52,447.79	1.5	$ 79,000.00	
	Ductile Iron Flanged Process Pipe, Valves, Fittings	L.S.	1	$ 300,000	$ 300,000	Dec-18	11093.47	11636.56	$ 314,686.75	1.5	$ 473,000.00	*From Rutla*
	Welded S.S. Gas Pipe, Valves, Fittings	L.S.	1	$ 375,000	$ 375,000	Dec-18	11093.47	11636.56	$ 393,358.44	1.5	$ 591,000.00	*From Rutla*
	Paint Process Piping and Equipment	L.S.	1	$ 20,000	$ 20,000	Dec-18	11093.47	11636.56	$ 20,979.12	1.5	$ 32,000.00	*From Rutla*
	Combined Heat and Power (CHP) Unit:											
	100 kW Containerized CHP Unit with Gas Conditioning	L.S.	1	$ 700,000	$ 700,000	Mar-18	10958.79	11636.56	$ 743,293.01	1	$ 744,000.00	
	CHP Unit/Gas Conditioning Equipment Install	L.S.	1	$ 175,000	$ 175,000	Mar-18	10958.79	11636.56	$ 185,823.25	1.5	$ 279,000.00	
	Equipment Sub-total										**$ 4,238,000**	

Nantucket, MA - Anaerobic Digester Feasibility Study

Preliminary Opinion of Project Cost

Item No.	Description	Unit	Est. Qty.	Cost/Unit	Total Cost	Cost Ref. Date	Corresp. ENR-CCI	Current ENR-CCI	Extended Cost	"Nantucket Factor"	Final Cost
6	**Digester Complex Exterior**										
	Digester Wall Insulation	S.F.	3,700	$ 3	$ 11,100	Dec-18	11093.47	11636.56	$ 11,643.41	1.5	$ 18,000.00
	Architectural Finish for Digester Walls	S.F.	2,600	$ 15	$ 39,000	Dec-18	11093.47	11636.56	$ 40,909.28	1.5	$ 62,000.00
	Waste Gas Burner	L.S.	1	$ 55,000	$ 55,000	Dec-18	11093.47	11636.56	$ 57,692.57	1.5	$ 87,000.00
	Waste Gas Burner Installation	L.S.	1	$ 60,000	$ 60,000	Dec-18	11093.47	11636.56	$ 62,937.35	1.5	$ 95,000.00
	Digester Complex Exterior Sub-total										**$ 262,000**
7	**Instrumentation**										
	Digester Liquid Level Sensor	Ea.	2	$ 3,000.00	$ 6,000	Dec-18	11093.47	11636.56	$ 6,293.73	1.5	$ 10,000.00
	Digester Temperature Sensor	Ea.	2	$ 2,500.00	$ 5,000	Dec-18	11093.47	11636.56	$ 5,244.78	1.5	$ 8,000.00
	Digester Headspace Pressure Sensor	Ea.	2	$ 2,000.00	$ 4,000	Dec-18	11093.47	11636.56	$ 4,195.82	1.5	$ 7,000.00
	Digester Mixing Cannon Pressure Sensor	Ea.	2	$ 2,000.00	$ 4,000	Dec-18	11093.47	11636.56	$ 4,195.82	1.5	$ 7,000.00
	Gas to Flare Pressure Sensor	Ea.	1	$ 2,000.00	$ 2,000	Dec-18	11093.47	11636.56	$ 2,097.91	1.5	$ 4,000.00
	Gas to Boilers Flow Sensor	Ea.	2	$ 2,500.00	$ 5,000	Dec-18	11093.47	11636.56	$ 5,244.78	1.5	$ 8,000.00
	Outdoor alarm light with horn	Ea.	1	$ 2,500.00	$ 2,500	Dec-18	11093.47	11636.56	$ 2,622.39	1.5	$ 4,000.00
	Alarm Silence pushbutton	Ea.	1	$ 250.00	$ 250	Dec-18	11093.47	11636.56	$ 262.24	1.5	$ 1,000.00
	Intrinsically Safe Barriers for new Sensors	Ea.	19	$ 500.00	$ 9,500	Dec-18	11093.47	11636.56	$ 9,965.08	1.5	$ 15,000.00
	PLC	Ea.	1	$ 13,000.00	$ 13,000	Dec-18	11093.47	11636.56	$ 13,636.43	1.5	$ 21,000.00
	Programming	L.S.	1	$ 15,000.00	$ 15,000	Dec-18	11093.47	11636.56	$ 15,734.34	1.5	$ 24,000.00
	Uninterruptible Power Supply (U.P.S.)	Ea.	1	$ 200.00	$ 200	Dec-18	11093.47	11636.56	$ 209.79	1.5	$ 1,000.00
	Control Panel Modifications	L.S.	1	$ 65,000.00	$ 65,000	Dec-18	11093.47	11636.56	$ 68,182.13	1.5	$ 103,000.00
	Network Switch in DCP-1	Ea.	1	$ 320.00	$ 320	Dec-18	11093.47	11636.56	$ 335.67	1.5	$ 1,000.00
	Installation	L.S.	1	$ 20,000	$ 20,000	Dec-18	11093.47	11636.56	$ 20,979.12	1.5	$ 32,000.00
	Instrumentation Sub-total										**$ 246,000**

Nantucket, MA - Anaerobic Digester Feasibility Study

Preliminary Opinion of Project Cost

Item No.	Description	Unit	Est. Qty.	Cost/Unit	Total Cost	Cost Ref. Date	Corresp. ENR-CCI	Current ENR-CCI	Extended Cost	"Nantucket Factor"	Final Cost
				Construction Subtotal							**$ 12,730,000.00**
				Engineering (23%)							$ 2,930,000.00
				Project Contingencies (30%)							$ 4,700,000.00
				TOTAL OPINION OF PROJECT COST							**$ 20,360,000.00**

Notes:

1- *Engineering New Record (ENR) Construction Cost Index (CCI) for August 20 is 11636.56.*
2- *Subtotal amounts have been rounded to the next $1,000.*
3- *Overall anticipated project cost has been rounded to the next $10,000.*
4- *Anticipated costs have been developed based on similar recent projects, and equipment manufacturer's cost data.*
5- *Permitting costs have not been included.*
6- *Contractor's OH&P are included in the unit prices.*
7- *Start-up and Operator Training is included in the listed equipment costs.*
8- *Project costs have been developed without benefit of final design drawings. For planning level costs, a contingency of 30% should be carried.*
9- *Gravity flow from the proposed digester complex is assumed to go to the future Miacomet Pump Station, to be constructed at the WWTF site.*

Nantucket, MA - Anaerobic Digester Feasibility Study

Equivalent Uniform Annual Cost (EUAC)

			Notes:
Capitol Cost (with 30% planning level contingency)	$	20,360,000	
Anticipated Annual O&M (digester complex only)			
Electrical	$	-	*Assume Power Generated is used by WWTF and Digesters so no net added power costs.*
Heating (fuel)	$	-	*Assume heat generated is used by WWTF and Digesters so no net added fuel costs.*
Labor (digester complex only)	$	332,850	*1.5 full time equivalents plus labor burden (US average Labor Burden is 68.3% of total labor cost). Assumes a direct labor salary rate of $70,000/year.*
Chemicals/Consumables	$	20,000	*Assumed*
Equipement O&M	$	47,490	*3% of equipment capital cost only (no installation)*
Total Annual O&M (added)	$	400,340	
Approximate Ammortization Rate (MA SRF Program)		1.5%	
Approximate Loan Term (Years)		20	
Ammortized Capital Cost	$	1,184,952	
Annual O&M	$	400,340	
Total Equivalent Uniform Annual Cost	**$**	**1,590,000**	

Note:

1. No credit for power cost savings resulting from CHP power generated is used in this calculation.

2. No credit for heating fuel savings from excess CHP heat generation is included in this calculation.

3. Housing Choice Community rate is 1.5%.

Nantucket, MA - Anaerobic Digester Feasibility Study

Equivalent Uniform Annual Cost (EUAC)

			Notes:
Capitol Cost (with 30% planning level contingency)	$	20,360,000	
Anticipated Annual O&M (digester complex only)			
Electrical	$	-	*Assume Power Generated is used by WWTF and Digesters so no net added power costs.*
Heating (fuel)	$	-	*Assume heat generated is used by WWTF and Digesters so no net added fuel costs.*
Labor (digester complex only)	$	332,850	*1.5 full time equivalents plus labor burden (US average Labor Burden is 68.3% of total labor cost). Assumes a direct labor salary rate of $70,000/year.*
Chemicals/Consumables	$	20,000	*Assumed*
Equipement O&M	$	47,490	*3% of equipment capital cost only (no installation)*
Total Annual O&M (added)	$	400,340	
Approximate Ammortization Rate (MA SRF Program)		1.5%	
Approximate Loan Term (Years)		20	
Ammortized Capital Cost	$	1,184,952	
Annual O&M	$	400,340	
Total Equivalent Uniform Annual Cost	**$**	**1,590,000**	

Note:

1. No credit for power cost savings resulting from CHP power generated is used in this calculation.
2. No credit for heating fuel savings from excess CHP heat generation is included in this calculation.
3. Housing Choice Community rate is 1.5%.

APPENDIX E

FY 2019 Energy Office Report

TOWN OF
NANTUCKET
ENERGY OFFICE

MEMORANDUM

TO: Andrew Vorce, Director of Planning

FROM: Lauren Sinatra, Energy Coordinator

RE: FY2019: Update of Energy Office Activities

In FY 2019, the Town's Energy Office conducted professional and technical tasks related to municipal and island-wide energy policies, practices, and projects that deliver significant taxpayer savings through reduced energy costs, while contributing to overall community sustainability and economic development.

In FY 2019, Town facilities and vehicles consumed:

- 12,873,701 kWh of electricity (6% increase over FY 2018)
- 149,425 gallons of heating oil (22% less than FY 2018)
- 51,702 gallons of propane (25% less than FY 2018)
- 32,682 gallons of diesel fuel (6% less than FY2018)
- 126,915 gallons of gasoline (3% less than FY2018)

When normalized for weather patterns, the Town used 81,537 MMBTu in FY2019, at a total cost of $3,225,713 for all power and fuel (10% less usage and 2% higher cost than in FY2018).

The High School Wind Turbine produced 181 Megawatt-hours (MWh) of energy in FY2019, offsetting approximately 13.3% off the High School's electric load, at an estimated value of $28,960 in avoided electricity costs.

Among the achievements of the Energy Office in FY 2019 were the following:

- Managed the *Nantucket PowerChoice* municipal electric program, which secured a less expensive and greener electric supply for Nantucket electric customers. By the end of the 2019 Fiscal Year, enrollment in Nantucket PowerChoice grew to more than 11,400 electricity customers, which is 85% of all eligible accounts on Nantucket. The average program price of 9.07 ¢/kWh consistently beat National Grid's Basic Service rates, delivering over $6 Million in cumulative savings to local participants since program launch in April 2017 (approximately $500/year).

- Sold 191 Renewable Energy Certificates (RECs) generated by the High School wind turbine to Nantucket's Electric Aggregation Program. This transaction resulted in $3,172.25 for the Town and 191,000 kWh of clean, local power for *Nantucket Power*Choice program participants.

- Awarded over $100,000 in rebates to local residents who installed Solar-PV. Funding for the Town's *Local Solar Rebate* program is provided through a 0.1¢/kWh charge that is included in the *Nantucket Power*Choice program price.

- Managed HeatSmart Nantucket, a successful12-month outreach program that encouraged residents to transition from traditional fossil fuel-based systems to high-efficiency, lower-carbon heating and cooling alternatives. Under HeatSmart Nantucket, dozens of islanders took advantage of limited-time pricing and thousands of dollars in state and utility incentives for solar hot water and airsource heatpump ("minisplit") systems. The Energy Office hosted a series of public workshops and created an informational website, which continues to serve as a key resource for the interested public: www.heatsmartnantucket.org.

- Initiated Nantucket's Green Communities Designation: Secured a $5,000 grant from the Massachusetts Department of Energy Resources (DOER) to engage the Cape Light Compact for Green Communities Designation Technical Assistance; coordinated a series of "Stretch Energy Code" informational workshops for residents and building contractors.

- Secured a $7,500 grant award to support the purchase of the Town's first all-electric vehicle for the municipal fleet through the Massachusetts Electric Vehicle Incentive Program (MassEVIP). The all-electric, Nissan Leaf, is used primarily by the Department of Culture and Tourism.

- Initiated and managed a municipal solar procurement, which included a prioritized list of municipal sites most feasible for solar development, including the Surfside Wastewater Treatment Plant, Public Safety Facility, Wannacomet Water Co., Airport, DPW Compound, and the Schools.

  Secured a $12,500 grant from the Massachusetts Department of Energy Resources to engage an industry-leading Solar Consultant for project technical assistance. The bundled solar procurement was designed to secure the most cost-effective price for a 75-kW Solar PV system at the Surfside Wastewater Treatment Plant, for which a $200,000 MassDEP grant was secured to offset ~90% of the purchase price.

- Worked closely with National Grid to identify methods for reducing growth in electrical demand during peak periods, including battery deployment and other non-wires alternative strategies, and to publicize, schedule and manage no-cost home energy assessments for 479 Nantucket households. The energy assessments and associated energy saving measures (i.e. LEDs, weatherization, wifi thermostats, etc.) resulted in 1,327,528 kWh saved, an average of $685 in annual cost savings per home, and 408kW in island peak load reductions. The Energy Office also partnered with National Grid to host an AC-unit Recycling Event and assisted in the successful promotion of four designated "Refrigerator Recycling" pickup dates.

- Served as the Town's representative for matters pertaining to MA offshore wind development, including leading communications with several offshore wind developers seeking to build windfarms 14-25 miles off Nantucket's south shore and serving as the Town's liaison with the Bureau of Ocean Energy Management (BOEM)--the lead federal agency overseeing offshore windfarm permitting and development.

  Represented the Town's best interests in the many federal, state and local permitting reviews for the Vineyard Wind-1 Offshore Wind Farm, including chairing the Town's "Offshore Wind Workgroup" and participating in the Section 106 Review to minimize and mitigate the effects of the project on local historic resources. The Energy Coordinator also assisted in drafting formal comments on key findings such as BOEM's *Draft Environmental Impact Statement* and the *Finding of Adverse Effect* on the Nantucket Historic District-National Historic Landmark.

- Secured a $35,000 Planning Grant award from the Massachusetts Executive Office of Energy & Environmental Affairs to update and expand the 2011 Nantucket Energy Plan into a robust Climate Action Plan in FY2020.